United States Air Force
611th Air Support Group/
Civil Engineering Squadron

Elmendorf AFB, Alaska

Final

Risk Assessment

Bullen Point Radar Installation, Alaska

18 March 1996

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Bullen Point Radar Installation, Alaska

Prepared by:

ICF Technology Incorporated

18 March 1996

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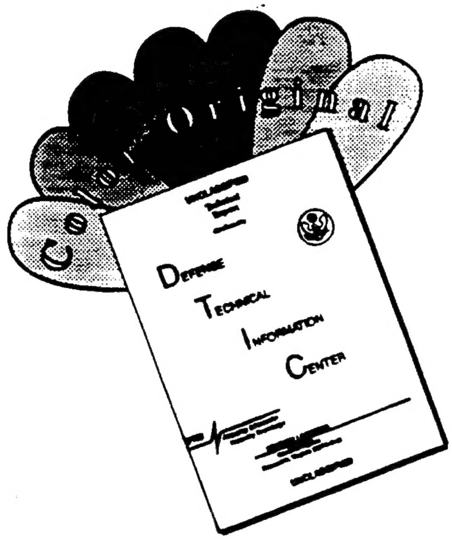

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PREFACE

This report presents the findings of Risk Assessments at sites located at the Bullen Point radar installation in northern Alaska. The sites were characterized based on sampling and analyses conducted during Remedial Investigation activities performed during August and September 1993. This report was prepared by ICF Technology Incorporated.

This report was prepared between January 1995 and March 1996. Mr. Samer Karmi of the Air Force Center for Environmental Excellence was the Alaska Restoration Team Chief for this task. Dr. Jerome Madden and Mr. Richard Borsetti of the 611th CES/CEVR were the Remedial Project Managers for the project.

Approved:

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Thomas McKinney
Program Director
ICF Technology Incorporated

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NOTICE

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LIST OF ACRONYMS AND ABBREVIATIONS

ADD	Average Daily Dose
Air Force	United States Air Force
ARAR	Applicable or Relevant and Appropriate Requirements
API	American Petroleum Institute
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factors
CDI	Chronic Daily Intake
COC	Chemicals of Concern
DEW	Distant Early Warning
DRPH	Diesel Range Petroleum Hydrocarbons
ECAO	Environmental Criteria and Assessment Office of EPA
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ha	Hectare
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
HSDB	Hazardous Substance Data Bank
HVOCs	Halogenated Volatile Organic Compounds
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IS	Onsite Dietary Intake
LADD	Lifetime Average Daily Dose

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

LOAEL	Lowest-Observed Adverse Effect Level
LOEL	Lowest Observed Effect Level
MDEP	Massachusetts Department of Environmental Protection
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
RBSLs	Risk-Based Screening Levels
RfD	Reference Dose
RIs	Remedial Investigations
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
RRPH	Residual Range Petroleum Hydrocarbons
SF	Slope Factor
SRR	Short Range Radar
SVOCs	Semi-Volatile Organic Compounds
TPH	Total Petroleum Hydrocarbon
TRVs	Toxicity Reference Values
TSCA	Toxic Substances Control Act
VOCs	Volatile Organic Compounds
UCL	Upper Confidence Limit
UF	Uncertainty factors
WOE	Weight-of-Evidence

1.0 INTRODUCTION

This document contains the baseline human health risk assessment and the ecological risk assessment (ERA) for the Bullen Point Distant Early Warning (DEW) Line radar installation. Five sites at the Bullen Point radar installation underwent remedial investigations (RIs) during the summer of 1993. The presence of chemical contamination in the soil, sediments, and surface water at the installation was evaluated and reported in the Bullen Point Remedial Investigation/Feasibility Study (RI/FS) (U.S. Air Force 1996). The analytical data reported in the RI/FS form the basis for the human health and ecological risk assessments. The primary chemicals of concern (COCs) at the five sites are diesel and gasoline from past spills and/or leaks. The general location of the Bullen Point radar installation is shown in Figure 1-1. The five sites investigated and the types of samples collected at each site are presented in Table 1-1. Figures of the five sites are presented in Section 2.0.

The purpose of the risk assessment is to evaluate the human and ecological health risks that may be associated with chemicals released to the environment at the five sites investigated during the RI. The risk assessment characterizes the probability that measured concentrations of hazardous chemical substances will cause adverse effects in humans or the environment in the absence of remediation. The risk assessment will be used to determine if remediation (site cleanup) is necessary and, if so, to rank sites for remedial action.

1.1 ORGANIZATION OF REPORT

Section 1.0 contains introductory information regarding the installation location and conditions, and a summary outline of the approach to the human health and ecological risk assessments. Section 2.0 is the Baseline Human Health Risk Assessment, and Section 3.0 is the Ecological Risk Assessment. References are presented in Section 4.0. Section 2.0, Baseline Human Health Risk Assessment, is composed of:

- **Selection of Site Contaminants**. Presents the chemicals of concern for human health and describes how they were selected for this risk assessment.

- **Exposure Assessment**. Identifies the pathways by which potential human exposures could occur, and estimates the magnitude, frequency, and duration of those exposures.

- **Toxicity Assessment**. Summarizes the toxicity of the selected COCs and the relationship between magnitude of exposure and the development of adverse health effects.

- **Risk Characterization**. Integrates the toxicity and exposure assessments to estimate the potential risks to human health from exposure to chemicals in environmental media.

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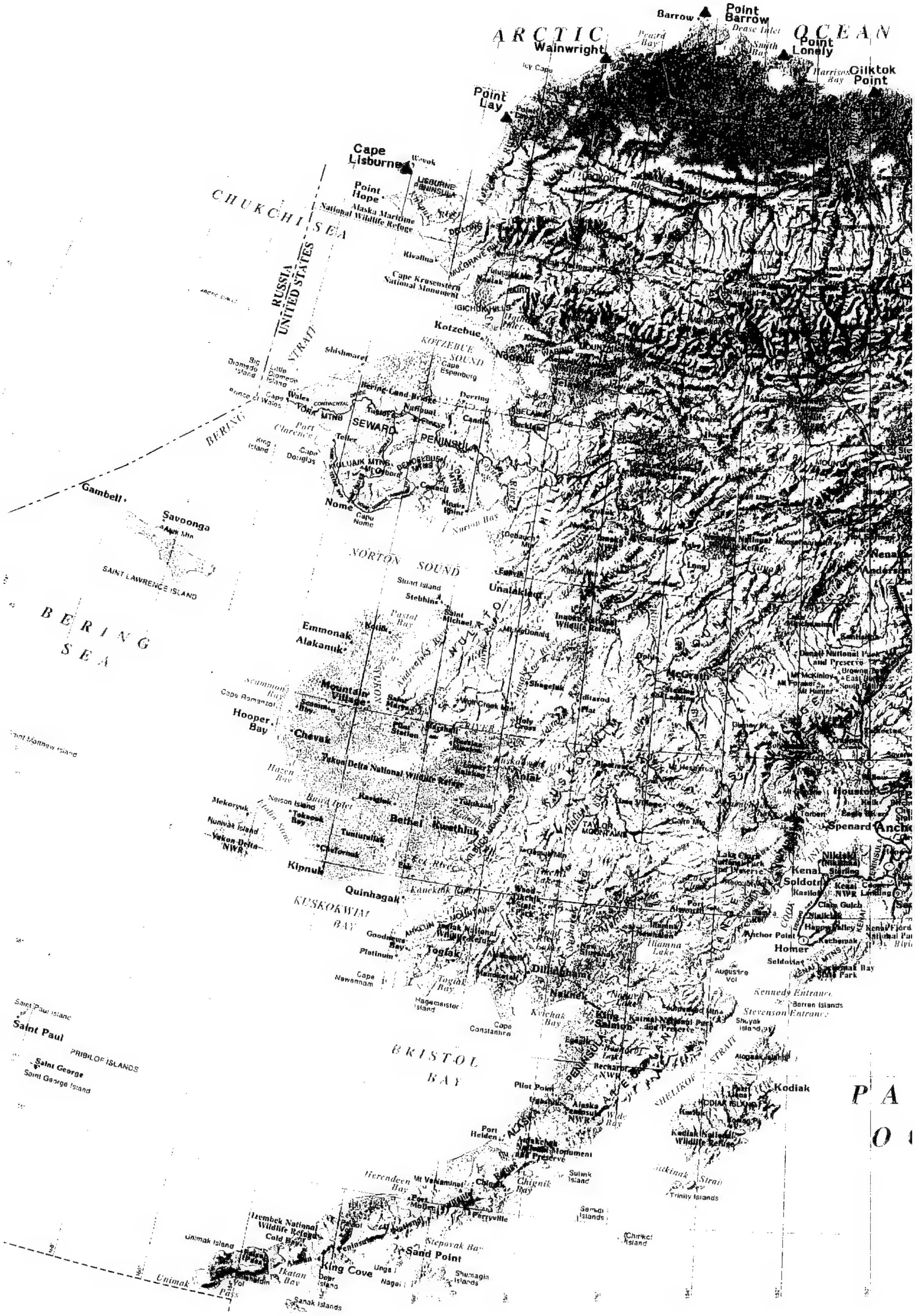

ARCTIC OCEAN
Barrow
Point Barrow
Wainwright
Point Lonely
Cilktok Point
Point Lay
Cape Lisburne
Point Hope
CHUKCHI SEA
RUSSIA
UNITED STATES
Kotzebue
KOTZEBUE SOUND
Shishmaref
SEWARD PENINSULA
BERING STRAIT
Nome
Gambell
Savoonga
SAINT LAWRENCE ISLAND
NORTON SOUND
Unalakleet
BERING SEA
Emmonak
Alakanuk
Hooper Bay
Chevak
Mountain Village
Yukon Delta National Wildlife Refuge
Bethel
Kipnuk
Quinhagak
KUSKOKWIM BAY
Togiak
Dillingham
Naknek
King Salmon
McGrath
Houston
Spenard
Kenai
Soldotna
Homer
Kodiak
BRISTOL BAY
Saint Paul
PRIBILOF ISLANDS
Saint George
Saint George Island
Pilot Point
Port Heiden
Chignik
Perryville
Sand Point
King Cove
Cold Bay
Unimak Island
Unimak Pass
Sanak Islands
Shumagin Islands
Trinity Islands
P A
O

2

LEGEND

▲ RADAR SITE

ALASKA REMOTE RADAR INSTALLATION

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FIGURE NO. 1-1

GENERAL LOCATION MAP

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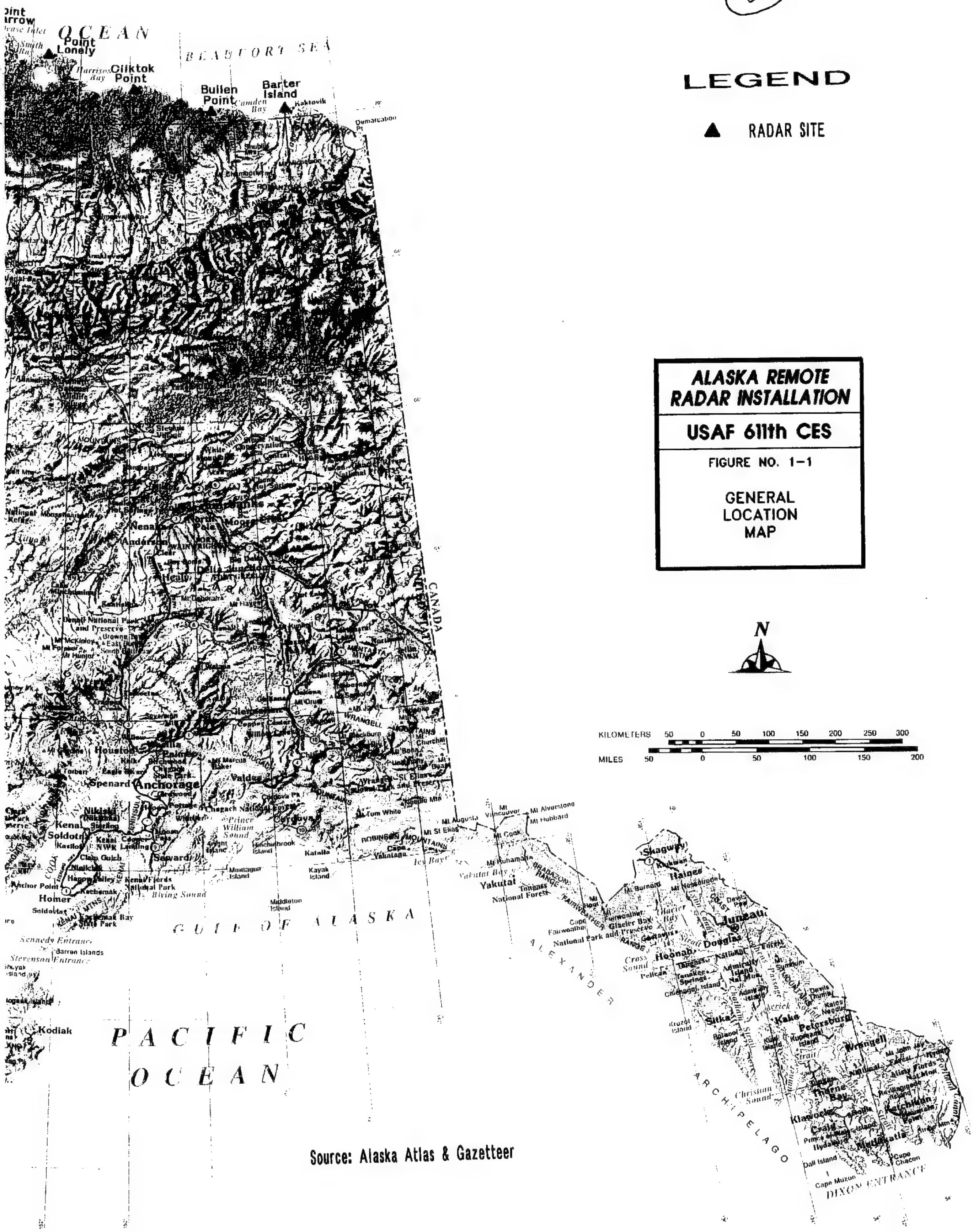


KILOMETERS 50 0 50 100 150 200 250 300

MILES 50 0 50 100 150 200

Source: Alaska Atlas & Gazetteer

TABLE 1-1. SITES EVALUATED AT BULLEN POINT DEW LINE INSTALLATION

SITE NAME	SITE ID NUMBER	SOIL	SEDIMENTS	SURFACE WATER
Inside Transformer[a]	OT04	X	NA	NA
POL Tanks	ST05	X	NA	X
Old Landfill/Dump Site East	LF06	X	X	X
Fuel Storage Area	ST09	X	X	X
Drum Storage Area	SS10	X	NA	NA

X Chemical analyses were performed on these media.
NA No chemical analysis was performed.
a In addition, three wipe samples were collected from inside the transformer building.

- **Risk Characterization Uncertainty**. Describes the potential shortcomings in the data and the methods used to develop the risk assessment, and the uncertainties in the interpretation of the data and the risk characterization results.

- **Risk Assessment Summary and Conclusions**. Presents a summary of, and conclusions regarding, the human health risks associated with exposure to contaminated media at the five sites at the Bullen Point DEW Line installation.

Section 3.0, the Ecological Risk Assessment (ERA), is composed of:

- **Selection of Site Contaminants**. Presents the COCs for ecological receptors and describes how they were selected for the ERA.

- **Ecological Exposure Assessment**. Identifies the potential receptors and representative species, habitat suitability, and exposure pathways.

- **Ecological Toxicity Assessment**. Describes the potential effects of site contaminants on the representative species.

- **Risk Characterization for Ecological Receptors**. Evaluates the likelihood of adverse effects on ecological receptors.

- **Ecological Uncertainty Analysis**. Describes the potential shortcomings in the data and the methods used to develop the ERA, and the uncertainties in the interpretation of the data and the ecological risk characterization results.

- **Ecological Risk Assessment Summary and Conclusions**. Presents a summary of ecological risks associated with contaminated media at the five sites at the Bullen Point DEW Line installation.

Appendix A contains the human health risk assessment spreadsheets used to estimate chemical intake, noncancer hazard, and excess lifetime cancer risk. Appendix B consists of toxicology profiles. The exposure equations and calculations for ecological receptors are presented in Appendices C through Appendix F. Appendix G contains a summary of RI sampling and analyses and the RI analytical data for all sites from which the COCs were selected and upon which the human health and ecological risk assessments are based.

1.2 RISK ASSESSMENT GUIDANCE DOCUMENTS

The following guidance documents were used to develop the human health and ecological risk assessments:

- *Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part A)* (EPA 1989a)

- Region 10 Supplemental Risk Assessment Guidance for Superfund (EPA 1991a)

- *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual* (EPA 1989b)

- General Guidance for Ecological Risk Assessment at United States Air Force Bases (MITRE 1990)

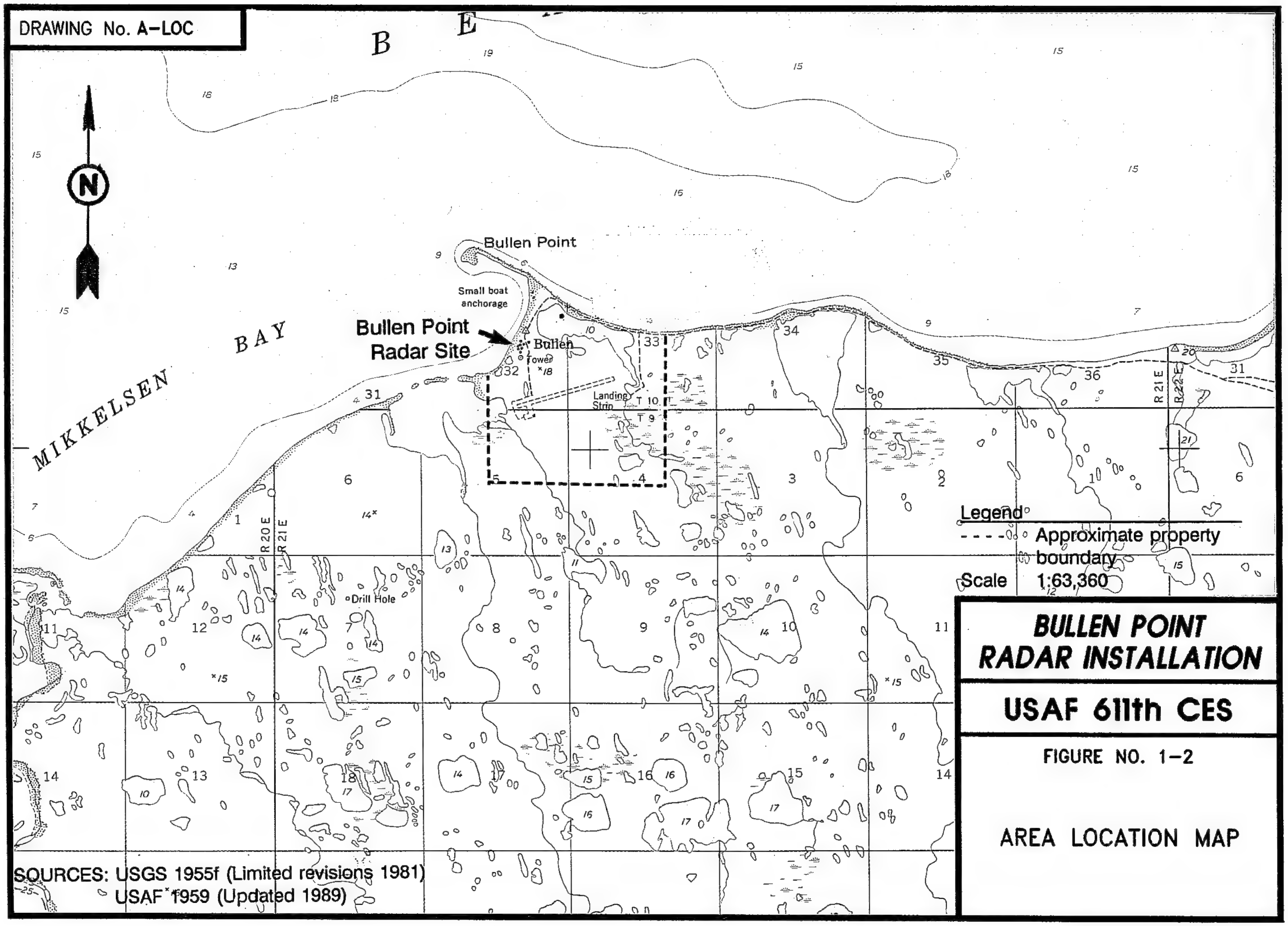
- Handbook to Support the Installation Restoration Program (IRP) Statements of Work (U.S. Air Force 1991).

- Framework for Ecological Risk Assessment (EPA 1992a)

1.3 INSTALLATION DESCRIPTION AND ENVIRONMENTAL SETTING

The Bullen Point radar installation, also known as POW-3, was operated as an auxiliary DEW Line station from 1953 to 1971 when it was deactivated. Inactive structures at the installation now include a radome, four 30-foot communications antennae, a module train of 10 buildings attached to the radome, two pumphouses, a warehouse, seven diesel oil tanks, a 250,000-gallon water storage tank, two barge docks, roads, gravel pads, and a 3,500-foot airstrip. A technical services building and a short range radar (SRR) tower have recently been constructed. The SRR is operated as an unmanned system.

The Bullen Point installation is located at 70°10'N, 146°50'W on Mikkelson Bay on the east central shore of the Beaufort Sea. An area location map is presented in Figure 1-2, and a site plan



BULLEN POINT RADAR INSTALLATION

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FIGURE NO. 1–2

AREA LOCATION MAP

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the installation is shown in Figure 1-3. The nearest populated area is Dead Horse located approximately 40 miles to the west. The installation occupies 620 acres of low lying tundra. The maximum elevation on Bullen Point is 18 feet above mean sea level, and drainage is radially away from the high points. An unnamed freshwater lake was located upgradient from the installation and was used as a drinking water supply when the station was active. The dam constructed to create the unnamed freshwater lake was breached when the station was deactivated.

The local geography includes shallow lagoons, thaw lakes, intermediate zones of polygonal ground, and upland areas of relatively flat tundra mat. A chain of barrier islands is located offshore.

Geologically the area consists of surficial deposits of sand and gravel near the shoreline and along stream channels; silt, sand, and gravel deposits in the inland low areas; and eolian silt and fine sand deposits in the upland areas. Permafrost underlies the entire installation.

Permafrost comprises geologic, hydrologic, and meteorologic characteristics that result in permanently frozen ground. Permafrost occurs in both unconsolidated sediments and bedrock. Its distribution is continuous on the Arctic Coastal Plain, and it has a significant impact on the flow of ground and surface water.

Permafrost acts as an impermeable barrier to the movement of groundwater because pore spaces are ice-filled in the zone of saturation. Recharge and discharge are, therefore, limited to unfrozen channels penetrating the permafrost zone. Permafrost restricts the downward percolation of water and increases runoff, enhancing the creation of lakes and swamps, and also restricts an aquifer's storage capacity and the number of locations from which groundwater may be withdrawn.

The interval between permafrost and ground surface is called the active zone because it freezes and thaws with seasonal weather changes. Water may be found in the active zone in the summer months. The thickness of the active zone at Bullen Point varied from approximately one to six feet during August and September 1993.

Oil exploration and production operations also occur in the area. Numerous oil wells have been drilled offshore on some of the barrier islands; however, no wells have been drilled near the Bullen Point installation.

1.3.1 Sites Evaluated at the Bullen Point DEW Line Installation

The Bullen Point radar installation was investigated to evaluate the possible contamination related to the United States Air Force (Air Force) activities and historical waste disposal practices. Five sites at the Bullen Point installation were determined to be of potential concern based on previous IRP sampling activities, literature review, pre-survey and reconnaissance trips, interviews of station personnel, and information on disposal practices at DEW Line stations. The sites were investigated during RI/FS activities to confirm the presence or absence of chemical contamination; define the extent and magnitude of confirmed chemical releases; gather adequate data to determine the magnitude of potential risks to human health and the environment; and

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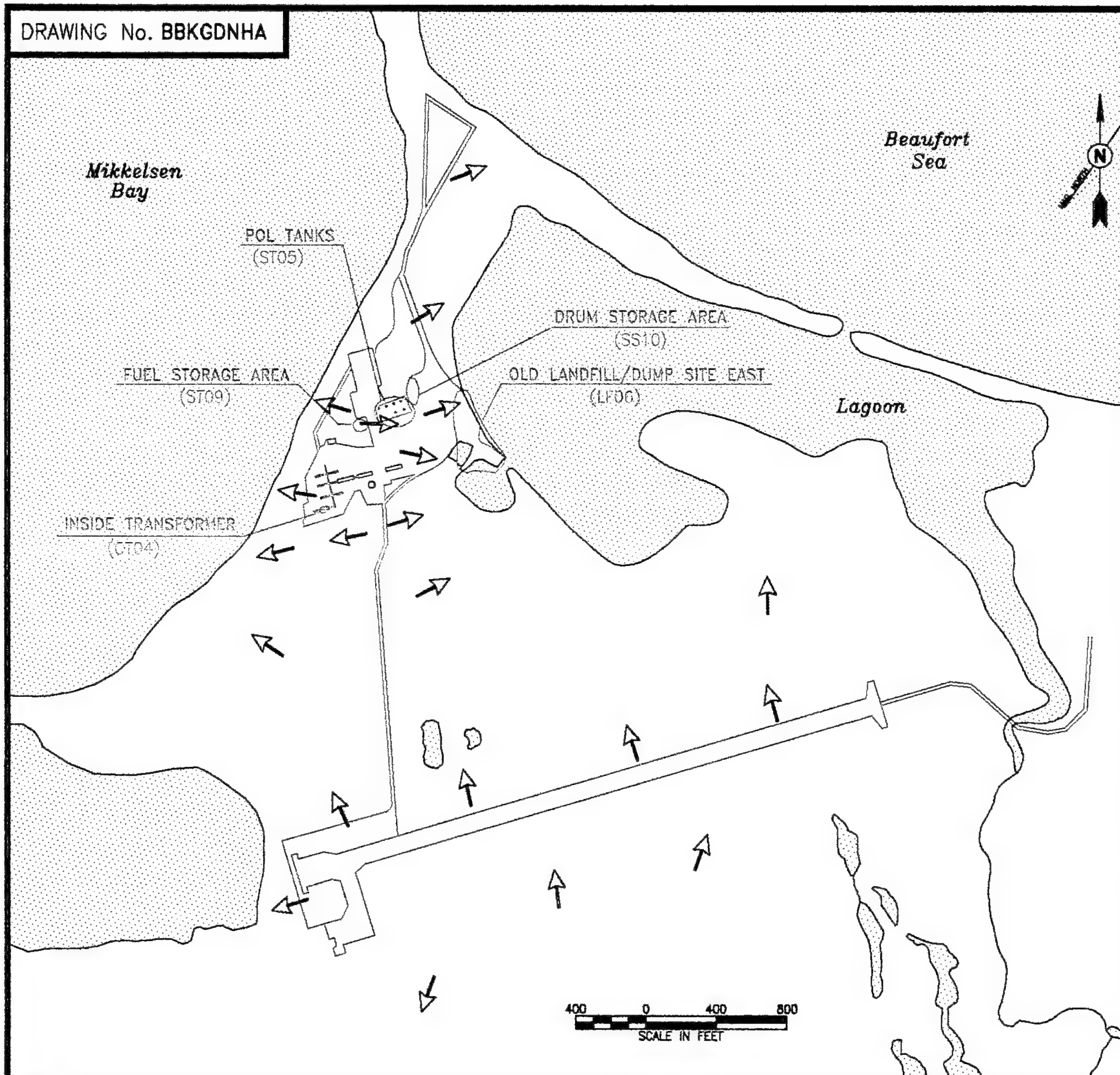

BULLEN POINT RADAR INSTALLATION

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FIGURE NO. 1-3

INSTALLATION SITE PLAN

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gather adequate data to identify and select the appropriate remedial actions for sites at which these risks exceed acceptable limits. The remainder of this section describes the five sites where sampling and chemical analyses were conducted during 1993 RI activities. All five sites at the installation investigated during the RI were evaluated in the risk assessment and are described below.

1.3.1.1 Inside Transformer (OT04). The Inside Transformer (OT04) site consists of the southwest section of the module train where the "inside transformer" was previously located and the associated soil and gravel below the former transformer location. A 1986 field reconnaissance trip by a previous contractor indicated that the transformer had leaked onto the surrounding floor tiles. The transformer and oil-covered floor tiles were removed in approximately 1989, but the transformer pad and some floor materials were not removed.

1.3.1.2 POL Tanks (ST05). The POL Tanks site is located northwest of the module train. The site consists of seven POL tanks and the associated pumphouse placed on a gravel pad. The three southern tanks are approximately 20,000 gallons each, and the four northern tanks are approximately 10,000 gallons each. A fill pipe extends from the northwest corner of the gravel pad to a tundra area to the north. The tanks were abandoned in 1971 when the Bullen Point installation was closed. Liquid level depth gauge readings indicate one of the tanks contains water and a sheen, and the other six tanks are empty.

1.3.1.3 Old Landfill/Dump Site East (LF06). The site was the location of the installation landfill from 1956 to 1971 (when the installation was deactivated); it is less than one acre in size. The Old Landfill site is located approximately 600 feet east of the module train and extends to the shore of a lagoon that opens to the sea. The landfill has been covered with soil and graded; however, minor erosion by ocean waves has caused some of the rusty metal debris to become exposed. The exposed rusty drums were empty, and there was no evidence that suggested any drums contained fluids.

1.3.1.4 Fuel Storage Area (ST09). The Fuel Storage Area (ST09) site is located approximately 100 feet west of the POL Tanks (ST05) site, and consists of a gravel pad that has been reworked and has an uneven surface. The Fuel Storage Area is deactivated and no structures exist at the site. The site was believed to have been used for storage of drummed fuel products. It was deactivated in 1971 with the rest of the installation.

1.3.1.5 Drum Storage Area (SS10). The site is located approximately 100 feet northeast of the POL Tanks (ST05) site. The Drum Storage Area site was used to stockpile drummed fluids such as solvents, antifreeze, and lube oil, and consists of a gravel pad area elevated approximately two feet above the tundra. Posts remain that supported a platform used to store the drums off the ground surface. The site was deactivated with the installation in 1971.

Table 1-1 contains a summary of the environmental media sampled at each of the sites. The analytical data obtained from these samples form the basis of the human health and ecological risk assessments presented in this document. Figures of the sites are presented in Section 2.0.

1.4 APPROACH TO HUMAN HEALTH RISK ASSESSMENT

The Bullen Point DEW Line installation presents a unique challenge in the development of a human health risk assessment. Many of the conventional assumptions applied in risk assessments do not apply to the North Slope of Alaska. Bullen Point is in a remote and unpopulated area. The nearest populated area is Deadhorse, approximately 40 miles to the west. Native residents of the North Slope, largely Inupiats, follow a lifestyle that includes a significant subsistence component; much of their food consists of mammals (whales, seals, moose, and caribou), aquatic life (arctic char), and birds (ptarmigan and ducks) that are abundant in this area of the arctic (Harcharek 1994). The climate is generally harsh, and the soil and surface water are frozen for approximately nine months of the year.

The general approach to the human health risk assessment was to quantify the excess lifetime cancer risk or the noncancer hazard for the site contaminants detected at each of the five sites at the installation. The maximum concentration of each chemical detected was used instead of an arithmetic mean or 95th percentile upper confidence limit (UCL) because contamination was detected infrequently and found to be generally of low concentration. Incorporating nondetects into the calculation of an average or UCL when the frequency of positive detects is low tends to yield low and unreliable estimates of contamination. Use of the maximum concentration yields a conservative estimate of risk or hazard.

To the extent possible, site-specific information was incorporated into the development of the exposure assumptions. The harsh climate naturally serves to limit exposure to contaminated soil, sediment, and surface water.

Residential exposure assumptions were used to reflect the upper-bound potential future risk. Several North Slope communities have requested use of inactive buildings at DEW Line installations; therefore, an evaluation using potential residential scenarios at the installation and sites was conducted.

Excess lifetime cancer risk and noncancer hazard were calculated for the soil/sediment ingestion and surface water ingestion pathways. Other pathways were eliminated from consideration as described in Section 2.2, the Human Health Risk Exposure Assessment.

1.5 APPROACH TO ECOLOGICAL RISK ASSESSMENT

The objective of the ERA is to estimate potential impacts to aquatic and terrestrial plants and animals at the Bullen Point radar installation. MITRE (1990) suggests that ERAs should "estimate the potential for occurrence of adverse effects that are manifested as changes in the diversity, health and behavior" of ecosystems. MITRE proposes that this can be accomplished by:

- Estimating the health risk to individual species;
- Evaluating the health of the community of exposed species; and

- Determining the potential adverse effects of contamination over several life cycles of the species under study.

Because this is a screening level assessment, the scope of this ERA is limited to the first task: estimating the risk to individual species. If a potential risk to individual species is identified, further work may be recommended to evaluate the community and life cycle effects. It is important to note that the health risk to an individual species is different from the health risk to an individual within a species. The former refers to population level biology, where the individual is not considered a relevant endpoint. The latter assesses the risks to an individual. In this ecological assessment, the individual is considered only in the case of threatened or endangered species.

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2.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The purpose of the baseline human health risk assessment for the Bullen Point DEW Line installation is to provide a basis for developing a risk management plan, including remedial action alternatives based on data from the RI/FS. The risk assessment develops numerical estimates of cancer risk and noncancer hazard for each site where sufficient information is available. Where information is not adequate to quantify noncancer hazard or cancer risk for a given COC, a qualitative discussion of the toxicity of that COC is provided in the toxicity profiles (Appendix B).

This baseline human health risk assessment addresses issues unique to this location as described in the introduction. It follows the conventional approach in that it is comprised of six sections:

- Identification of COCs - in which the chemicals detected in environmental samples are compared to risk-based screening levels (RBSLs) and concentrations considered to be applicable or relevant and appropriate requirements (ARARs);
- Exposure assessment - in which the frequency, duration, and magnitude of potential exposures to the COCs are estimated;
- Toxicity assessment - in which the toxicology of the COCs is assessed;
- Risk characterization - in which the potential for adverse health effects in humans as a result of exposure to the COCs is quantified (as appropriate) or qualitatively discussed; and
- Uncertainty assessment - in which the general sources of uncertainty in the risk assessment process and the site-specific sources of uncertainty are discussed.
- Risk assessment summary and conclusions - in which the human health risks are summarized for each of the sites and conclusions based on these risks are presented.

2.1 IDENTIFICATION OF CHEMICALS OF CONCERN

COCs for human health were selected for each site at the Bullen Point facility based on comparison of chemical concentrations to naturally-occurring background concentrations, RBSLs, ARARs, and safe levels of essential human nutrients (e.g., calcium, magnesium, sodium, and potassium).

This section discusses the RI sampling strategy and an evaluation of data prior to screening (Section 2.1.1), describes and presents equations for calculating RBSLs (Section 2.1.2), identifies chemicals that are essential human nutrients (Section 2.1.3), describes the collection of background samples (Section 2.1.4), and discusses the selection of COCs (Section 2.1.5).

2.1.1 Sampling Strategy and Evaluation of Analytical Data

The RI sampling strategy at the Bullen Point sites was to characterize the nature and extent of potential contamination at each site. Suspected source areas were sampled to determine the concentrations of contaminants, if any, at the areas likely to have the highest concentrations. Migration pathways from the source areas were sampled to determine the extent, if any, that the contaminants had migrated from the sites. If no discernable pathways were evident, an attempt was made to sample around the source areas to determine the extent of site contaminants. Quick turn-around analyses were conducted on samples from the first sampling event, and a second round of sampling was conducted at those sites where further characterization of the nature and extent of contamination was needed.

Sample types included surface and subsurface soil/sediment samples and surface water samples. In almost all cases, samples were discrete grab samples from one sample location. Surface soil and sediment samples were collected in gravel and tundra areas at or near the ground surface (from ground surface to approximately six inches in depth). Subsurface soil samples were mainly collected in gravel pad areas where unsaturated conditions allowed vertical migration of contaminants. Sediment samples were collected below shallow ponds or streams, or in areas that visually appeared to have been previously covered with water. Surface water samples were collected from ponds, streams, springs, or leachate areas. Surface water samples underwent both total and dissolved metal analyses; however, the total metal analytical results were used in the risk assessment. A summary of the 1993 RI sampling and analyses conducted at the installation is presented in Appendix G.

Before screening for COCs, the results of the RI sampling program were sorted by medium (i.e., soil, sediment, and surface water) and reviewed for quality. The review included an evaluation of the analytical methods used, sample quantitation limits, and qualified data, and a comparison to background levels and laboratory and field blanks. Analytical data were reviewed for completeness, comparability, representativeness, precision, and accuracy. In addition, data validation qualifiers were considered in assessing the quality of the data. The review and validation of analytical data determined that a minimal amount of data was not usable. These data were qualified with an "R" and were not used in the risk assessment.

As outlined in the Risk Assessment Guidance for Superfund (EPA 1989a), site data were compared to available blank (laboratory, field, and trip) data. The data from blanks are presented in Appendix G. In accordance with EPA (1989a), if the detected concentration in a sample was less than 10 times the concentration from blanks for common laboratory contaminants (e.g., acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters) the chemical was not selected for evaluation in the risk assessment. For those organic or inorganic chemicals that are not considered by the U.S. Environmental Protection Agency (EPA) to be common laboratory contaminants (all other compounds), if the detected concentration was less then five times the maximum concentration detected in the blanks, the chemical was not selected for evaluation in the risk assessment.

2.1.2 Risk-Based Screening Levels

An RBSL is a chemical concentration in a particular medium that yields a given cancer risk or hazard quotient (HQ) (e.g., 10^{-7} cancer risk; 0.1 HQ) under a given set of conditions. For Bullen Point, the RBSLs were calculated for soil based on EPA default reasonable maximum exposure (RME) parameters (EPA 1991a). In developing the RBSLs, the most recent toxicity factors available from the Integrated Risk Information System (IRIS) and the Health Effects Assessment Summary Tables (HEAST) were used. IRIS and HEAST are databases of toxicity information for human health risk assessment maintained by the Environmental Criteria and Assessment Office (ECAO) of the EPA. The information presented on IRIS represents the consensus of EPA scientists regarding the toxicity of chemicals released to the environment. Toxicity factors that EPA has withdrawn from IRIS and HEAST, or available from other sources, were not used in this risk assessment.

2.1.2.1 Formulae for Calculating RBSLs. The RBSL concentrations were derived using equations in EPA Region 10 guidance (EPA 1991a). The equations are also presented in a slightly different form in the Risk Assessment Guidance for Superfund Volume I, Part B (EPA 1991b). Exposure assessment and risk characterization algorithms for human health risk assessments use site-specific contaminant concentration data, factors describing exposure, and toxicity dose-response values [e.g., reference doses (RfDs) or carcinogen slope factors (SFs)]. These risk assessment algorithms were solved for the concentration term to derive the RBSL for soil and surface water. The algorithms are summarized as follows:

$$\text{Risk} = C \times \left(\frac{CR \times EFD}{BW \times AT}\right) \times SF \quad \text{or} \quad HQ = C \times \left(\frac{CR \times EFD}{BW \times AT}\right) / RfD \qquad \textbf{EQUATION 1, 2}$$

Risk = Target Cancer Risk
C = Concentration
CR = Contact Rate
EFD = Exposure Frequency and Duration
BW = Body Weight
AT = Averaging Time
SF = Slope Factor
HQ = Target Hazard Quotient
RfD = Reference Dose

RBSLs are calculated based on a specific target cancer risk or HQ. EPA (1991a) recommends that a 1×10^{-7} target cancer risk and a target noncancer HQ of 0.1 be used for soil and a 1×10^{-6} risk and 0.1 HQ be used for surface water. The lower target cancer risk is used for screening soil because additional pathways, such as dermal contact and inhalation, are not accounted for by the calculations (EPA 1991a).

Equations (1) and (2) shown above are rearranged to solve for the concentration term (i.e., the RBSL):

$$C = \text{Risk} \Big/ \left(\left(\frac{CR \times EFD}{BW \times AT}\right) \times SF\right) \quad \text{or} \quad C = HQ \Big/ \left(\left(\frac{CR \times EFD}{BW \times AT}\right) / RfD\right) \qquad \textbf{EQUATION 3, 4}$$

Surface Water Ingestion Equations. Using standard default exposure factors (EPA 1989b) for water ingestion, the equation for cancer risk from drinking water ingestion becomes:

$$\text{Risk} = C\ (\mu g/L) \times 0.001\ mg/\mu g \times \left(\frac{2\ L/day \times 350\ day/year \times 30\ year}{70\ kg \times 70\ year \times 365\ day/year} \right) \times SF_o \qquad \textbf{EQUATION 5}$$

Equation 5 can be rearranged to solve for a RBSL with, for example, a target cancer risk of 10^{-6}:

$$C\ (\mu g/L) = 10^{-6} \times 1{,}000\ \mu g/mg \Big/ \left[\left(\frac{2\ L/day \times 350\ day/year \times 30\ year}{70\ kg \times 70\ year \times 365\ day/year} \right) \times SF_o \right] \qquad \textbf{EQUATION 6}$$

For non-carcinogens, the equation for the HQ for drinking water ingestion is:

$$HQ = C\ (\mu g/L) \times 0.001\ mg/\mu g \times \left(\frac{2\ L/day \times 350\ day/year \times 30\ year}{70\ kg \times 30\ year \times 365\ day/year} \right) / RfD_o \qquad \textbf{EQUATION 7}$$

Equation 7 can be rearranged to provide an equation for the concentration that represents an HQ of 1 from ingestion:

$$C\ (\mu g/L) = 1 \times 1{,}000\ \mu g/mg \Big/ \left[\left(\frac{2\ L/day \times 350\ day/year \times 30\ year}{70\ kg \times 30\ year \times 365\ day/year} \right) / RfD_o \right] \qquad \textbf{EQUATION 8}$$

Soil or Sediment Ingestion Equations. The equation for calculating carcinogenic risk from soil or sediment ingestion, combining child (subscript c) and adult (subscript a) exposure, is as follows:

$$\text{Risk} = C\ (mg/kg) \times 0.000001\ kg/mg \times \qquad \textbf{EQUATION 9}$$

$$\left[\left(\left(\frac{200_c\ mg/day \times 350_c\ day/year \times 6\ year}{15_c\ kg \times 365\ day/year} \right) + \left(\frac{100_a\ mg/day \times 350_a\ day/year \times 24\ year}{70_a\ kg \times 365\ day/year} \right) \right) / 70\ year \right] \times SF_o$$

Equation 9 can be rearranged to solve for the concentration that represents a target cancer risk of 10^{-7}:

$$C\ (mg/kg) = 10^{-7} \times 1{,}000{,}000\ mg/kg / \qquad \textbf{EQUATION 10}$$

$$\left[\left(\left(\frac{200_c\ mg/day \times 350_c\ day/year \times 6\ year}{15_c\ kg \times 365\ day/year} \right) + \left(\frac{100_a\ mg/day \times 350_a\ day/year \times 24\ year}{70_a\ kg \times 365\ day/year} \right) \right) / 70\ year \right] \times SF_o$$

For non-carcinogens in soil, Equation 11 is used to calculate the HQ:

HQ = C (mg/kg) x 0.000001 kg/mg x **EQUATION 11**

$$\left[\left(\frac{200_c \text{ mg/day} \times 350_c \text{ day/year} \times 6 \text{ year}}{15_c \text{ kg} \times 365 \text{ day/year}}\right) + \left(\frac{100_a \text{ mg/day} \times 350_a \text{ day/year} \times 24 \text{ year}}{70_a \text{ kg} \times 365 \text{ day/year}}\right) / 30 \text{ year}\right] / RfD_o$$

Equation 11 can be rearranged to solve for the concentration that represents an HQ of 0.1:

C (mg/kg) = 0.1 x 1,000,000 mg/kg / **EQUATION 12**

$$\left[\left(\left(\left(\frac{200_c \text{ mg/day} \times 350_c \text{ day/year} \times 6 \text{ year}}{15_c \text{ kg} \times 365 \text{ day/year}}\right) + \left(\frac{100_a \text{ mg/day} \times 350_a \text{ day/year} \times 24 \text{ year}}{70_a \text{ kg} \times 365 \text{ day/year}}\right)\right) / 30 \text{ year}\right) / RfD_o\right]$$

2.1.3 Screening of Chemicals by Comparing Maximum Detected Concentrations of Essential Human Nutrients

Based on EPA's guidance (1991a), calcium, magnesium, potassium, iron, and sodium are considered to be essential human nutrients and were eliminated from the human health risk assessment at the screening stage. These chemicals are often detected but are not toxic to humans except at extremely high doses. No quantitative toxicity information is available for these elements from EPA sources; therefore, these metals are not selected as COCs for this risk assessment.

2.1.4 Concentrations of Organic and Inorganic Constituents in Background Samples

Four soil, one sediment, and two surface water samples were collected upgradient (relative to surface drainage) of the radar installation to determine the background concentrations of naturally occurring organic constituents in soil, sediment, and surface water (Figure 2-1). Although some naturally occurring compounds were detected in some of the soil and sediment background samples in the diesel range petroleum hydrocarbons (DRPH) analyses, the organic concentration in background samples is assumed to be non-detect. This conservative approach was used because it is not possible to determine to what degree, if any, the DRPH detected in site samples were naturally occurring compounds. Soil and sediment background samples were collected from a depth of zero to six inches.

In order to obtain a representative range of background inorganic (metal) concentrations in soil, sediments, and surface waters of the North Slope, 44 samples (29 soil or sediment, and 15 water) from seven North Slope radar installations were collected to establish the naturally occurring background concentrations. In addition to Bullen Point, the installations are Barter Island, Oliktok Point, Point Lonely, Point Barrow, Point Lay, and Wainwright. Approximately four soil/sediment and two surface water background samples were collected and analyzed for metals at each of the seven radar installations. In determining potential risks in surface water, total metal

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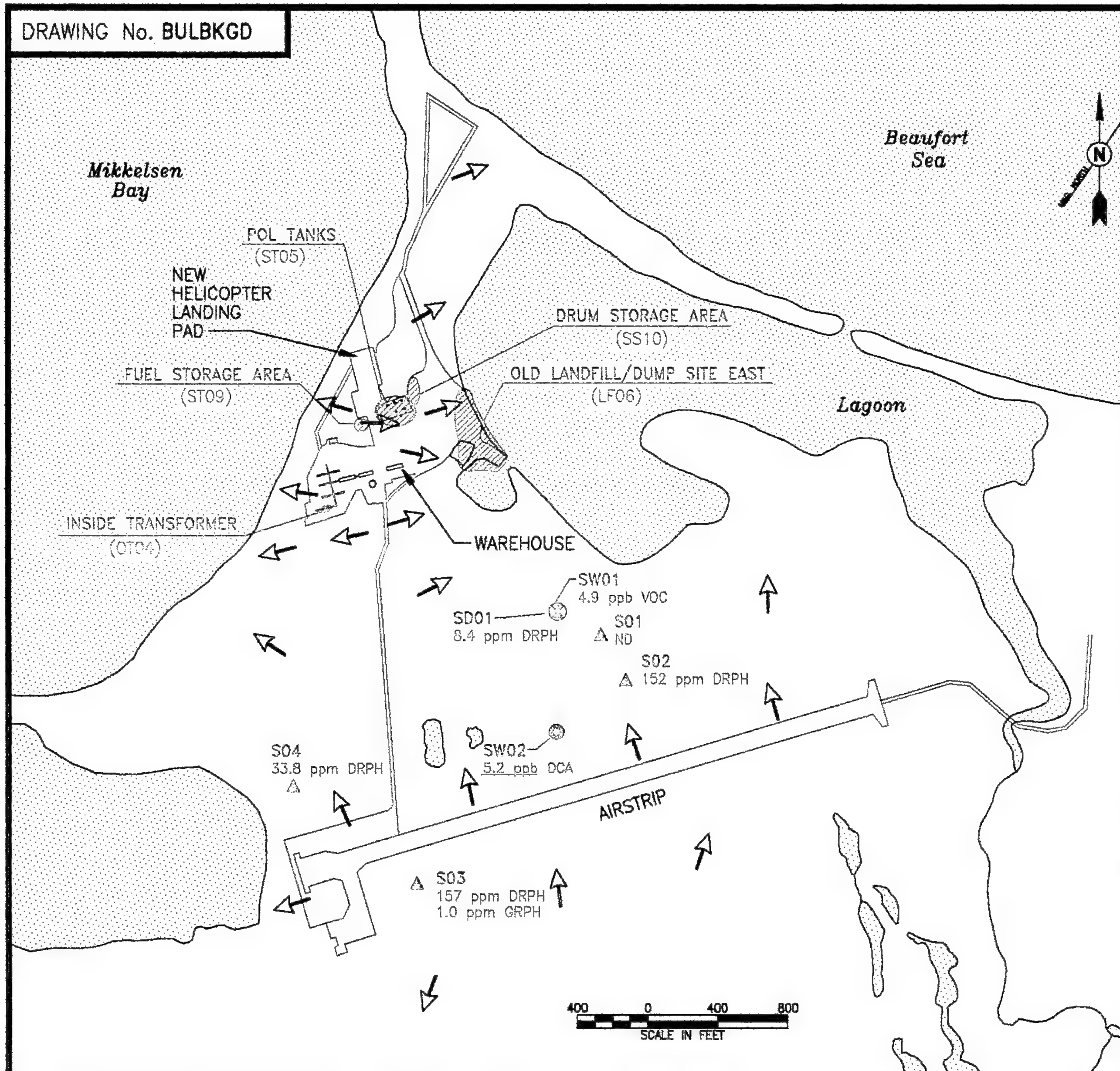
DRAWING No. BULBKGD



ND	NO CONTAMINATION DETECTED
VOC	TOTAL ORGANIC COMPOUNDS
DRPH	DIESEL RANGE PETROLEUM HYDROCARBONS
GRPH	GASOLINE RANGE PETROLEUM HYDROCARBONS
DCA	1,2-DICHLOROETHANE

LEGEND

- BUILDINGS, STRUCTURES
- ROADS
- SOIL SAMPLE
- SURFACE WATER SAMPLE
- SEDIMENT AND WATER SAMPLES
- SURFACE WATER
- GRAVEL PAD BOUNDARY
- SURFACE DRAINAGE
- 2.6 ppm CT&E DATA
- RI AREAS OF CONCERN

BULLEN POINT RADAR INSTALLATION

USAF 611th CES

FIGURE NO. 2-1

BACKGROUND (BKGD) SAMPLE LOCATIONS AND ANALYTICAL RESULTS

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concentrations were used in the risk assessment. Analytical results for background samples collected at Bullen Point are presented in Appendix G.

2.1.5 Selection of Chemicals of Concern

Soil and Sediment. The maximum concentrations of the chemicals detected in soil or sediment samples at the Bullen Point installation and not considered to be essential human nutrients were compared, on a site-by-site basis, to the corresponding background concentrations, RBSLs, and where available, federal or state ARARs. Chemicals detected without an RBSL or ARAR were retained as COCs if concentrations exceeded background levels. A chemical with an RBSL or ARAR was selected as a COC for soil and sediment if the maximum concentration at which the chemical was detected exceeded the corresponding background concentration and the RBSL (based either on cancer risk or noncancer hazard) or ARAR (Table 2-1). Thus, for example, the maximum concentration of Aroclor 1254 (0.9 mg/kg) at the Inside Transformer (OT04) exceeds the background range, the RBSLs based on cancer risk and noncancer hazard, and the ARAR for polychlorinated biphenyls (PCBs) promulgated in the Toxic Substances Control Act (TSCA). Therefore, Aroclor 1254 was selected as a COC for the soils at the Inside Transformer site.

The COCs for soil/sediment at each site were compared to background concentrations, RBSLs, and ARARs in Table 2-1. The chemicals retained as COCs exceed background concentrations, and the RBSL or an ARAR. A chemical was not retained if the level detected was less than the corresponding RBSL and ARAR, even though background levels were exceeded. The COCs selected that exceed background levels, but do not have an RBSL or an ARAR are discussed below. The COCs selected at each site that exceed an RBSL, ARAR, or both are discussed in Sections 2.1.5.1 to 2.1.5.5.

Surface Water. The maximum concentrations of the chemicals detected in surface water samples at Bullen Point were compared, on a site-by-site basis, to the corresponding background concentrations, RBSLs, and where available, federal or state ARARs. Chemicals detected without an RBSL or ARAR were retained as COCs if concentrations exceeded background levels. A chemical with an RBSL or ARAR was selected as a COC for surface water if the maximum concentration at which the chemical was detected exceeded the corresponding background concentration, and the RBSL (based either on cancer risk or noncancer hazard) or ARAR (Table 2-1). Thus, for example, the maximum concentration of DRPH (298 μg/L) at the POL Tanks (ST05) exceeds the RBSL based on noncancer hazard (292 μg/L). Therefore, DRPH were selected as a COC for the surface water at the POL Tanks (ST05) site.

The concentrations of DRPH detected in two subsurface water samples (GW01 and GW02 from the POL Tanks site) were not used in the risk evaluation because the hand-augured bore hole these samples were collected from likely cross-contaminated the samples. The maximum concentrations of GRPH, VOCs, and SVOCs detected in these samples, however, were used in the risk assessment.

The COCs for surface water at each site were compared to background concentrations, RBSLs, and ARARs in Table 2-1. The chemicals retained as COCs exceed background concentrations and the RBSL or an ARAR. A chemical was not retained if the level detected was less than the

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT BULLEN POINT

SITE	MATRIX	CHEMICAL DETECTED	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL[a]		ARAR[b]	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
Inside Transformer (OT04)	Soil	Aroclor 1254	0.9J	mg/kg	<0.2	0.00831[c]	0.540	10[d]	**Yes**
POL Tanks	Soil	DRPH	5,860	mg/kg	<4.00-157	--	--	500[e]	**Yes**
(ST05)		GRPH	170	mg/kg	<0.500-1.03	--	--	100[e]	**Yes**
		Benzene	0.031N	mg/kg	<0.025-<0.04	2.21	--	0.5[e]	No
		Toluene	0.423N	mg/kg	<0.025-<0.04	--	5,400	--	No
		Ethylbenzene	1.29	mg/kg	<0.025-<0.04	--	2,700	--	No
		Xylenes (total)	4.43	mg/kg	<0.050-<0.08	--	54,000	--	No
		n-Butylbenzene	0.174J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		p-Isopropyltoluene	0.112J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		Naphthalene	0.902J	mg/kg	<0.025-<0.035	--	1,100	--	No
		1,2,4-Trimethylbenzene	0.944	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		1,3,5-Trimethylbenzene	5.82	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		2-Methylnaphthalene	1.2	mg/kg	<0.240-<1.00	--	--	--	**Yes***
		di-n-Butylphthalate	0.571	mg/kg	<0.240-<1.00	--	2,700	8,000[f]	No
		bis-(2-Ethylhexyl)phthalate	0.306	mg/kg	<0.240-<1.00	4.57	540	50[f]	No
		Aluminum	11,000	mg/kg	1,500-25,000	--	--	--	No
		Barium	130	mg/kg	27-390	--	1,890	--	No
		Beryllium	3.8	mg/kg	<2.6-6.4	0.0149	135	--	No
		Calcium	55,000J	mg/kg	350-59,000	--	--	--	No
		Chromium	18	mg/kg	<4.3-47	--	135	--	No
		Copper	12	mg/kg	<2.7-45	--	999	--	No
		Iron	15,000	mg/kg	5,400-35,000	--	--	--	No
		Magnesium	3,[illegible]J	mg/kg	360-7,400	--	--	--	No

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT BULLEN POINT (CONTINUED)

SITE	MATRIX	CHEMICAL DETECTED	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL[a]		ARAR[b]	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
POL Tanks	Soil	Manganese	73J	mg/kg	25-290	--	3,780	--	No
(ST05)	(Continued)	Nickel	16	mg/kg	4.2-46	--	540	--	No
(Continued)		Potassium	950	mg/kg	<300-2,200	--	--	--	No
		Sodium	220	mg/kg	<160-680	--	--	--	No
		Vanadium	28	mg/kg	6.3-59	--	189	--	No
		Zinc	29	mg/kg	9.2-95	--	8,100	--	No
	Water	DRPH in subsurface water[i]	423,000	µg/L	<200	--	292	--	No[l]
		DRPH in surface water	298						Yes
		GRPH[i]	723	µg/L	<20	50	730	--	Yes
		Benzene[i]	2	µg/L	<1	0.617	--	5[g]	Yes
		Toluene[i]	4N	µg/L	<1	--	96.5	1,000[h]	No
		Ethylbenzene[i]	13N	µg/L	<1	--	158	700[h]	No
		Xylenes (total)[i]	34N	µg/L	<2	--	7,300	10,000[h]	No
		1,2-Dichloroethane[i]	2.6	µg/L	1.9B-4.5B	0.934	--	5[g]	No[l]
		p-Isopropyltoluene[i]	15	µg/L	<1	--	--	--	Yes*
		Naphthalene[i]	8.7	µg/L	<1	--	150	--	No
		1,2,4-Trimethylbenzene[i]	35	µg/L	<1	--	--	--	Yes*
		1,3,5-Trimethylbenzene[i]	62	µg/L	<1	--	--	--	Yes*
		2-Methylnaphthalene[i]	6,500J	µg/L	<10	--	--	--	Yes*
Old Landfill/Dump Site	Soil/Sediment	DRPH	219	mg/kg	<4-157	--	--	500[e]	No
East (LF06)		bis(2-Ethylhexyl)Phthalate	0.447	mg/kg	<0.240-<1.00	4.57	540	50[f]	No
		4-Methylphenol	0.58	mg/kg	<0.240-<1.00	--	135	--	No
		di-n-Butylphthalate	0.74	mg/kg	<0.240-<1.00	--	2,700	8,000[f]	No

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT BULLEN POINT (CONTINUED)

SITE	MATRIX	CHEMICAL DETECTED	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL[a]		ARAR[b]	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
Old Landfill/Dump Site East (LF06) (Continued)	Soil/Sediment (Continued)	Aluminum	2,400	mg/kg	1,500-25,000	--	--	--	No
		Barium	32	mg/kg	27-390	--	1,890	--	No
		Calcium	34,500	mg/kg	360-59,000	--	--	--	No
		Chromium	18	mg/kg	<4.3-47	--	135	--	No
		Copper	13	mg/kg	<2.7-45	--	999	--	No
		Iron	7,400	mg/kg	5,400-35,000	--	--	--	No
		Lead	40	mg/kg	<5.1-22	--	--	500[j]	No
		Magnesium	1,680	mg/kg	360-7,400	--	--	--	No
		Manganese	76	mg/kg	25-290	--	3,780	--	No
		Nickel	7.5	mg/kg	4.2-46	--	540	--	No
		Sodium	690	mg/kg	<160-680	--	--	--	No
		Vanadium	8	mg/kg	6.3-59	--	189	--	No
		Zinc	34	mg/kg	9.2-95	--	8,100	--	No
	Surface Water	DRPH	1,870	µg/L	<200	--	292	--	**Yes**
		Toluene	1.2	µg/L	<1	--	96.5	1,000[h]	No
		Ethylbenzene	7.6	µg/L	<1	--	158	700[h]	No
		Xylenes (Total)	19.2	µg/L	<2	--	7,300	10,000[h]	No
		Aluminum	610	µg/L	<100-350	--	--	--	**Yes***
		Barium	74	µg/L	<50-93	--	256	2,000[k]	No
		Calcium	50,000	µg/L	4,500-88,000	--	--	--	No
		Iron	3,600	µg/L	180-2,800	--	--	--	No
		Magnesium	18,000	µg/L	2,900-53,000	--	--	--	No

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT BULLEN POINT (CONTINUED)

SITE	MATRIX	CHEMICAL DETECTED	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL[a] CANCER	RBSL[a] NON-CANCER	ARAR[b]	CHEMICAL OF CONCERN
Old Landfill/Dump Site	Surface Water	Manganese	130	µg/L	<50-510	--	18.3	--	No
East (LF06) (Continued)	(Continued)	Sodium	78,000	µg/L	8,200-450,000	--	--	--	No
Fuel Storage Area	Soil/Sediment	DRPH	3,830J	mg/kg	<4-157	--	--	500[e]	**Yes**
(ST09)		GRPH	406	mg/kg	<0.5-1.03	--	--	100[e]	**Yes**
		Benzene	0.035	mg/kg	<0.025-<0.04	2.2	--	0.5[e]	No
		Toluene	0.533J	mg/kg	<0.025-<0.04	--	5,400	--	No
		Ethylbenzene	1.57	mg/kg	<0.025-<0.04	--	2,700	--	No
		Xylenes (Total)	6.63	mg/kg	<0.05-<0.08	--	54,000	--	No
		n-Butylbenzene	0.857J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		sec-Butylbenzene	0.303J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		Naphthalene	4.37J	mg/kg	<0.025-<0.035	--	1,100	--	No
		1,2,4-Trimethylbenzene	2.71J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		1,3,5-Trimethylbenzene	0.848J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		Isopropylbenzene	0.170J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		p-Isopropyltoluene	0.581J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		n-Propylbenzene	0.259J	mg/kg	<0.025-<0.035	--	--	--	**Yes***
		2-Methylnaphthalene	3.32	mg/kg	<0.240-<1.00	--	--	--	**Yes***
		di-n-Butylphthalate	0.534	mg/kg	<0.240-<1.00	--	2,700	8,000[f]	No
	Surface Water	DRPH	554	µg/L	392-457	--	292	--	**Yes**
		1,2-Dichloroethane	1.7	µg/L	1.9B-4.5B	0.934	--	5[j]	No[l]
Drum Storage Area	Soil	DRPH	775[J]	mg/kg	<4.00-157	--	--	500[e]	**Yes**
(SS10)		GRPH	14.3	mg/kg	<0.500-1.03	--	--	100[e]	No
		Aluminum	1,400	mg/kg	1,500-25,000	--	--	--	No
		Barium	19	mg/kg	27-390	--	1,890	--	No

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT BULLEN POINT (CONTINUED)

SITE	MATRIX	CHEMICAL DETECTED	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL[a]		ARAR[b]	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
Drum Storage Area	Soil	Calcium	1,900J	mg/kg	360-59,000	--	--	--	No
(SS10)	(Continued)	Chromium	2.7	mg/kg	<4.3-47	--	135	--	No
(Continued)		Copper	3.4	mg/kg	<2.7-45	--	999	--	No
		Iron	4,300	mg/kg	5,400-35,000	--	--	--	No
		Magnesium	1,100J	mg/kg	360-7,400	--	--	--	No
		Manganese	45J	mg/kg	25-290	--	3,780	--	No
		Nickel	4.7	mg/kg	4.2-46	--	540	--	No
		Sodium	52	mg/kg	<160-680	--	--	--	No
		Vanadium	4.1	mg/kg	6.3-59	--	189	--	No
		Zinc	14	mg/kg	9.2-95	--	8,100	--	No

* Chemicals without an RBSL or ARAR are considered chemicals of potential concern and are discussed in Section 2.1.5.
a Risk-Based Screening Level.
b Applicable or Relevant and Appropriate Requirement.
c RBSL for Aroclor 1254 based on cancer risk is derived from the PCB SF.
d TSCA Cleanup Level.
e ADEC 1991.
f 55 FR 30798, Proposed Rule RCRA Corrective Action for SWMUs 40 CFR [Section 264.521 (a)(2)(i-iv)], Health-Based Criteria for Systematic Toxicants and Carcinogens.
g MCL, 52 FR 25690.
h MCL, 56 FR 3526 (30 January 1991).
i These analytes were detected in water samples collected from shallow bore holes. They may not be indicative of the true concentration analytes present in subsurface water at the site; therefore, the DRPH concentration in samples GW01 and GW02 was not used in the risk assessment. The concentrations of GRPH, VOCs, and SVOCs detected in these samples were evaluated in the risk assessment.
j EPA 1991d.
k MCL, 56 FR 30266 (01 July 1991).
l 1,2-Dichloroethane was detected in the majority of blank and background samples. Site concentration did not exceed five times the maximum detected concentration in blank samples, therefore, it was not selected as a COC.
B The analyte was detected in associated blank.
J Result is an estimate.
N The analysis indicates the presence of analyte for which there is presumptive evidence to make a "tentative identification".

corresponding RBSL and ARAR, even though background levels were exceeded. The COCs selected that exceed background levels, but do not have an RBSL or ARAR are discussed below. The COCs at each site that exceed an RBSL, ARAR, or both, are discussed in Sections 2.1.5.1 to 2.1.5.5.

Risk Characterization of Chemicals without RBSLs and ARARs. Several chemicals detected above background levels could not be thoroughly screened because an RBSL could not be calculated and no ARAR was available (Table 2-1). The cancer risk and noncancer hazard for these chemicals cannot, therefore, be quantified. A list of these chemicals is presented in Table 2-2.

This section is a qualitative discussion of the potential for these chemicals to cause toxicity among the receptor groups identified at the Bullen Point installation. The essential human nutrients were discussed in Section 2.1.3 and will not be discussed further here. Essential nutrients are not considered COCs in this risk assessment.

The American Petroleum Institute (API) recently published an evaluation of the environmental fate, transport, and toxicity of twelve organic chemicals found frequently in petroleum products. The twelve were selected from a large list of "candidates" based on:

- abundance in crude and refined petroleum products, including residual and used oils;
- chemical/physical properties that represent a range of mobilities in soil and solubilities in aqueous environments; and
- toxicity in mammals and aquatic organisms (API 1994).

Two of the chemicals detected at the Point Barrow installation, 1,2,4-trimethylbenzene and naphthalene, were selected from the list of twelve chemicals (API 1994) and are used in this risk assessment as surrogates for the chemicals without RBSLs and ARARs. These chemicals have similar chemical structures and, therefore, will represent the substituted benzenes and the polynuclear aromatic hydrocarbons that do not have toxicity criteria (Table 2-2).

1,2,4-Trimethylbenzene has a low order of toxicity in mammals (API 1994). No effect was observed on the kidneys of rats that received 0.5 or 2.0 g/kg orally five days per week for four weeks. Inhalation of high concentrations of 1,2,4-trimethylbenzene produces central nervous system depression in humans and rats. Lung toxicity, including bronchitis, pneumonitis, and edema, was also observed in humans. 1,2,4-Trimethylbenzene has not been observed to be carcinogenic or mutagenic in laboratory studies of rats and cultured mammalian cells. Potential exposure of receptors to 1,2,4-trimethylbenzene at the Bullen Point installation would probably be limited to oral ingestion of soil and at the maximum concentration measured (2.71 mg/kg soil)

TABLE 2-2. CHEMICALS WITHOUT RBSLS AND ARARS OBSERVED IN THE SOIL, SEDIMENT, OR SURFACE WATER AT THE BULLEN POINT INSTALLATION

SUBSTITUTED BENZENES
1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene
p-Isopropyltoluene
Isopropylbenzene
n-Propylbenzene
n-Butylbenzene
ESSENTIAL HUMAN NUTRIENTS
Calcium
Iron
Magnesium
Potassium
Sodium
POLYCYCLIC AROMATIC HYDROCARBONS
2-Methylnaphthalene
OTHER
Aluminum

would be expected to be nontoxic.[1] For the purposes of this risk assessment, 1,2,4-trimethylbenzene is considered to be a reasonable surrogate for the substituted benzenes observed at the Bullen Point installation.

Because of the lack of toxicology information available for 2-methylnaphthalene, naphthalene will be used as a surrogate in this discussion of chemicals without RBSLs and ARARs. Naphthalene has a low order of toxicity in mammals (API 1994). The toxicology of this chemical has been well characterized in several species, including humans, rats, rabbits, and mice. The toxicity in humans is known from cases of accidental or intentional (suicide) ingestion of contaminated food

[1] Based on the following calculation: assume average daily soil ingestion rate of 200 mg of soil per day and 2.71 mg of 1,2,4-trimethylbenzene per kg of soil (maximum concentration measured at Bullen Point installation). This yields a dose of 0.000008 mg of 1,2,4-trimethylbenzene per kg body weight per day. The oral dose of 1,2,4-trimethylbenzene received by rats that showed no kidney effects was equivalent to 2,000 mg of 1,2,4-trimethylbenzene per kg body weight, which is more than 250,000,000 times greater than the estimated dose for potential receptors at the Bullen Point installation.

or mothballs, and the most common effect is liver damage (jaundice) and destruction of red blood cells resulting in anemia. These effects occur at exposure levels that far exceed the levels to which the receptor groups at the Bullen Point installation could be exposed. Dose-response information is available from studies in rats, mice, and rabbits. High doses of naphthalene administered over several days to one month resulted in cataract formation and other less serious ocular effects. High doses administered over several days to three months produced mild toxic effects on the liver, lung, kidney, and immunological system. The no effect level of oral exposure in these species occurs in the range of 100 to 300 mg naphthalene per kg body weight per day (100 to 300 mg/kg/day). The oral exposure levels to 2-methylnaphthalene that may occur through soil ingestion at the Bullen Point installation are 0.000009 mg/kg/day. Furthermore, the maximum concentration of 2-methylnapthalene is less than the RBSL for naphthalene. Therefore, any exposure to 2-methylnaphthalene in the soil or surface water at the Bullen Point installation is expected to be nontoxic.[2]

The metal without an RBSL and ARAR which is listed in the "Other" category of Table 2-2 is not expected to pose a significant hazard to the receptor groups identified at the Bullen Point installation. Aluminum was detected in a surface water sample at 610 µg/L. EPA's ECAO has issued a provisional reference dose for aluminum of 1 mg/kg/day. Based on the provisional criteria, aluminum is expected to be non-toxic[3] at the concentrations detected.

In conclusion, the chemicals discussed above have been marked in Table 2-1 as potential COCs to indicate that there is some uncertainty in screening out these chemicals. Without toxicity criteria the potential risks of these chemical cannot be quantified. However, based on the information presented above and the concentrations measured at the sites, these chemicals are not expected to pose a heath risk.

Chemicals with RBSLs and/or ARARs. Following are discussions of the COCs at each site that exceeded background levels and an RBSL, ARAR, or both. Table 2-3 is a summary of the COCs selected for the sites at the Bullen Point installations.

2.1.5.1 Inside Transformer (OT04). Aroclor 1254 was identified as a COC for the soil matrix at the Inside Transformer (Figure 2-2). The concentration of Aroclor 1254 exceeded the background concentration and the RBSLs based on cancer risk and noncancer hazard. The ARAR based on TSCA, however, was not exceeded (Table 2-1). The RBSL for cancer risk was based on the cancer SF for PCBs. Although it is a member of the PCB family, Aroclor 1254 has not been assigned to an EPA carcinogen weight-of-evidence (WOE) group.

Three wipe samples were collected from the floor of the transformer building to evaluate the presence of PCBs. Aroclor 1254 was measured in these samples at concentrations ranging from 18.9 $\mu g/100\ cm^2$ to 391.1 $\mu g/100\ cm^2$. The assessment of noncancer hazard and cancer risk that

[2] Based on the following assumptions: soil ingestion rate, 200 mg/day; drinking water ingestion rate, 2 L/day; 70 kg body weight for typical receptor; maximum soil concentration of 2-methylnaphthalene, 3.32 mg/kg.

[3] Based on the following assumptions: drinking water ingestion rate, 2 L/day; 70 kg body weight for typical receptor; and maximum surface water concentration of 610 µg/L.

TABLE 2-3. SUMMARY OF THE CHEMICALS OF CONCERN AT BULLEN POINT

SITE	CHEMICALS OF CONCERN	
	SOIL/SEDIMENT	SURFACE WATER
Inside Transformer (OT04)	Aroclor 1254	NONE
POL Tanks (ST05)	DRPH GRPH	DRPH GRPH Benzene
Old Landfill/Dump Site East (LF06)	NONE	DRPH
Fuel Storage Area (ST09)	DRPH GRPH	DRPH
Drum Storage Area (SS10)	DRPH	NONE

* The summary of COCs on this table includes only those chemicals detected that exceed background levels and an RBSL, ARAR, or both. COCs that exceeded background levels but do not have an RBSL or ARAR are discussed in Section 2.1.5. (Page 2-15).

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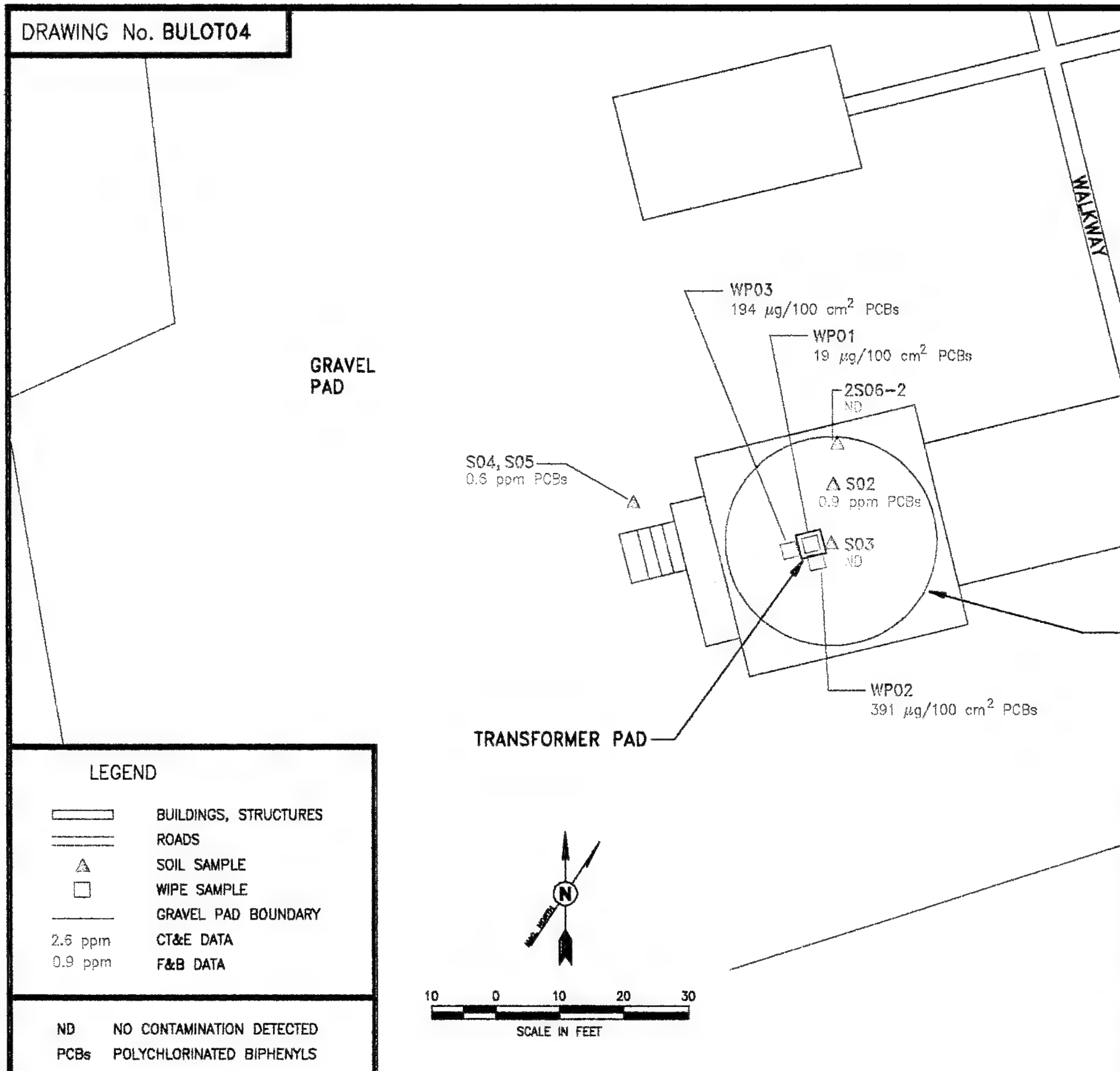

BULLEN POINT RADAR INSTALLATION

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FIGURE NO. 2-2

INSIDE TRANSFORMER (OT04) SAMPLE LOCATIONS AND ANALYTICAL RESULTS

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may be associated with exposure to the PCBs at this site, however, will be limited to the potential ingestion of soil. The remediation of the PCBs present on the floor of the transformer building will be discussed in the Bullen Point Feasibility Study.

No surface water bodies were identified at the Inside Transformer site; therefore, no surface water COCs have been identified (Figure 2-2).

2.1.5.2 POL Tanks (ST05). DRPH and GRPH were identified as COCs for the soil matrix at the POL Tanks site (Figure 2-3). The maximum concentrations of DRPH and GRPH exceeded their background concentrations and the ARAR concentrations for petroleum hydrocarbon contamination of soil (ADEC 1991) (Table 2-1).

DRPH were identified as a COC for the surface water at the POL Tanks site (Figure 2-3). The concentration of DRPH in surface water slightly exceeded the RBSL based on noncancer hazard (Table 2-1). GRPH and benzene were detected in shallow boreholes and identified as COCs because their maximum concentrations exceeded the RBSLs based on cancer risk.

2.1.5.3 Old Landfill/Dump Site East (LF06). No COCs were identified for the soil matrix at the Old Landfill/Dump Site East (Figure 2-4) based on a comparison of the maximum concentrations of detected chemicals to their background, RBSL, and ARAR concentrations (Table 2-1).

DRPH were identified as a COC for the surface water at the Old Landfill/Dump Site East (Figure 2-4). The maximum concentration of DRPH exceeded the RBSL based on the noncancer hazard associated with drinking surface water contaminated with petroleum hydrocarbons (Table 2-1).

2.1.5.4 Fuel Storage Area (ST09). DRPH and GRPH were identified as COCs for the soil matrix at the Fuel Storage Area site (Figure 2-5). The maximum concentrations of DRPH and GRPH exceeded their background concentrations and the ARAR concentrations for petroleum hydrocarbon contamination of soil (ADEC 1991) (Table 2-1).

DRPH were identified as a COC for the surface water at the Fuel Storage Area (Figure 2-5). The maximum concentration of DRPH exceeded the RBSL based on the noncancer hazard associated with drinking surface water contaminated with petroleum hydrocarbons (Table 2-1).

2.1.5.5 Drum Storage Area (SS10). DRPH were identified as a COC for the soil matrix at the Drum Storage Area site (Figure 2-6). The maximum concentration of DRPH exceeded the background concentration and the ARAR concentration for petroleum hydrocarbon contamination of soil (ADEC 1991) (Table 2-1).

No surface water bodies were identified at the Drum Storage Area; therefore, no surface water COCs have been identified (Figure 2-6).

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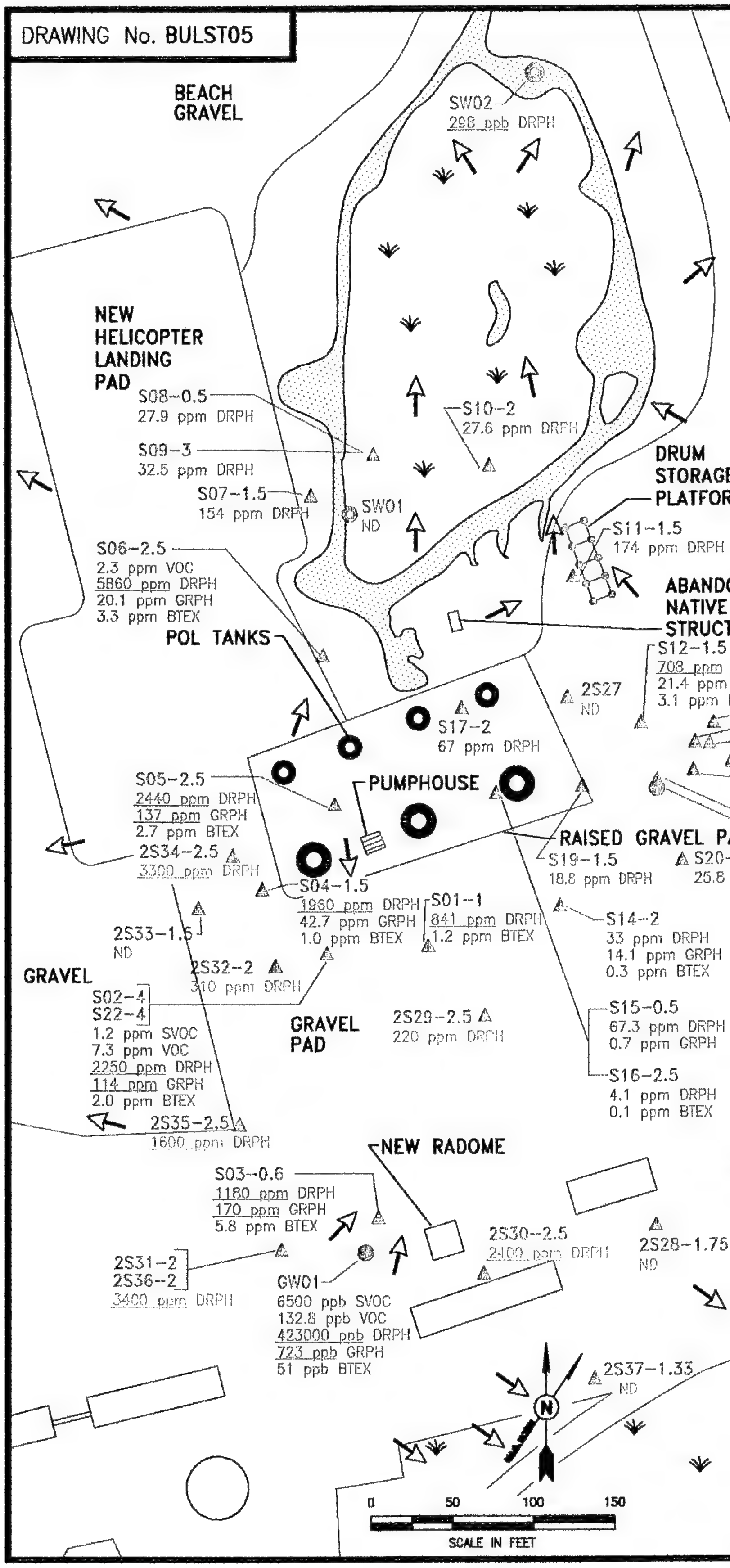

BULLEN POINT RADAR INSTALLATION

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FIGURE NO. 2-3

POL TANKS (ST05) SAMPLE LOCATIONS AND ANALYTICAL RESULTS

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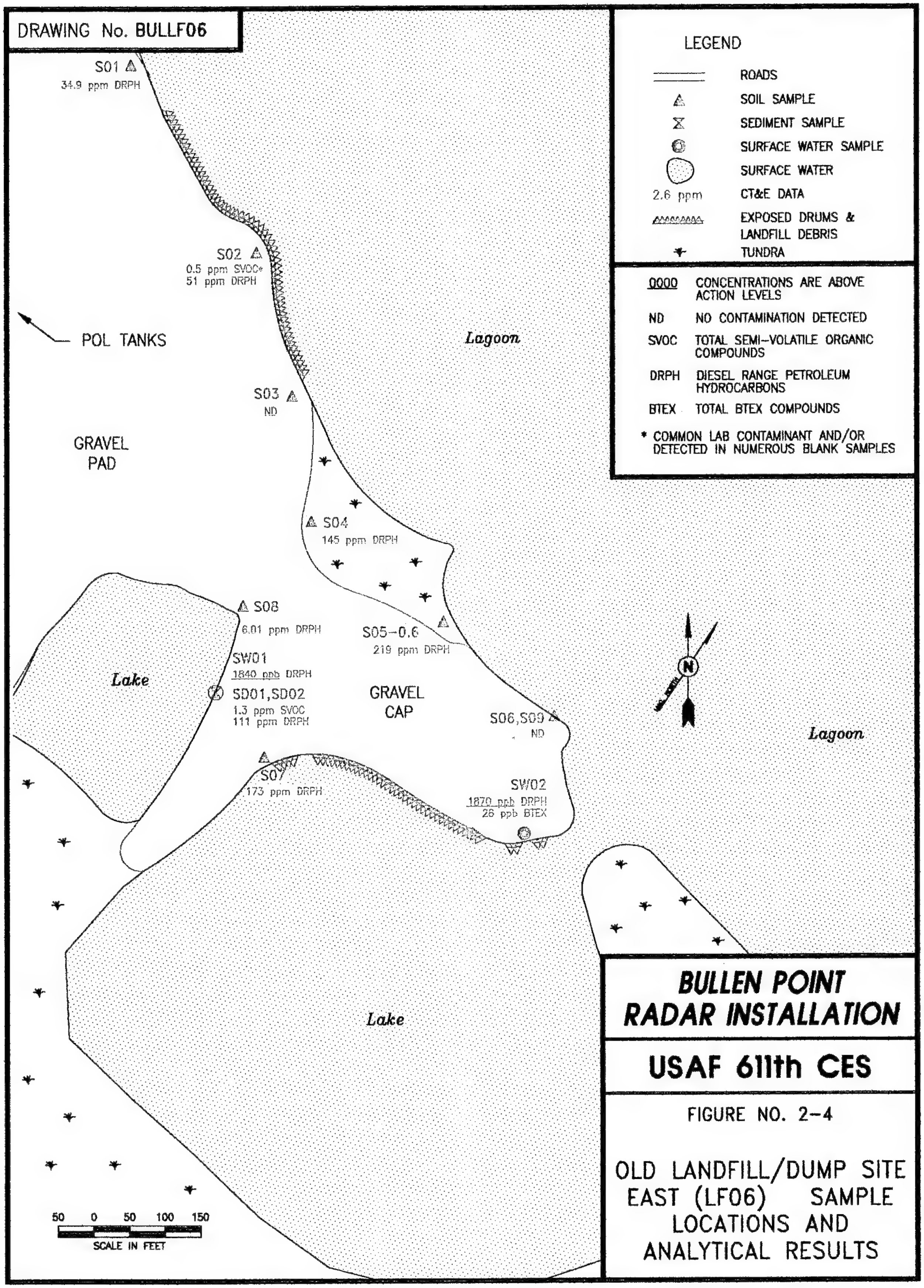

BULLEN POINT RADAR INSTALLATION

USAF 611th CES

FIGURE NO. 2-4

OLD LANDFILL/DUMP SITE EAST (LF06) SAMPLE LOCATIONS AND ANALYTICAL RESULTS

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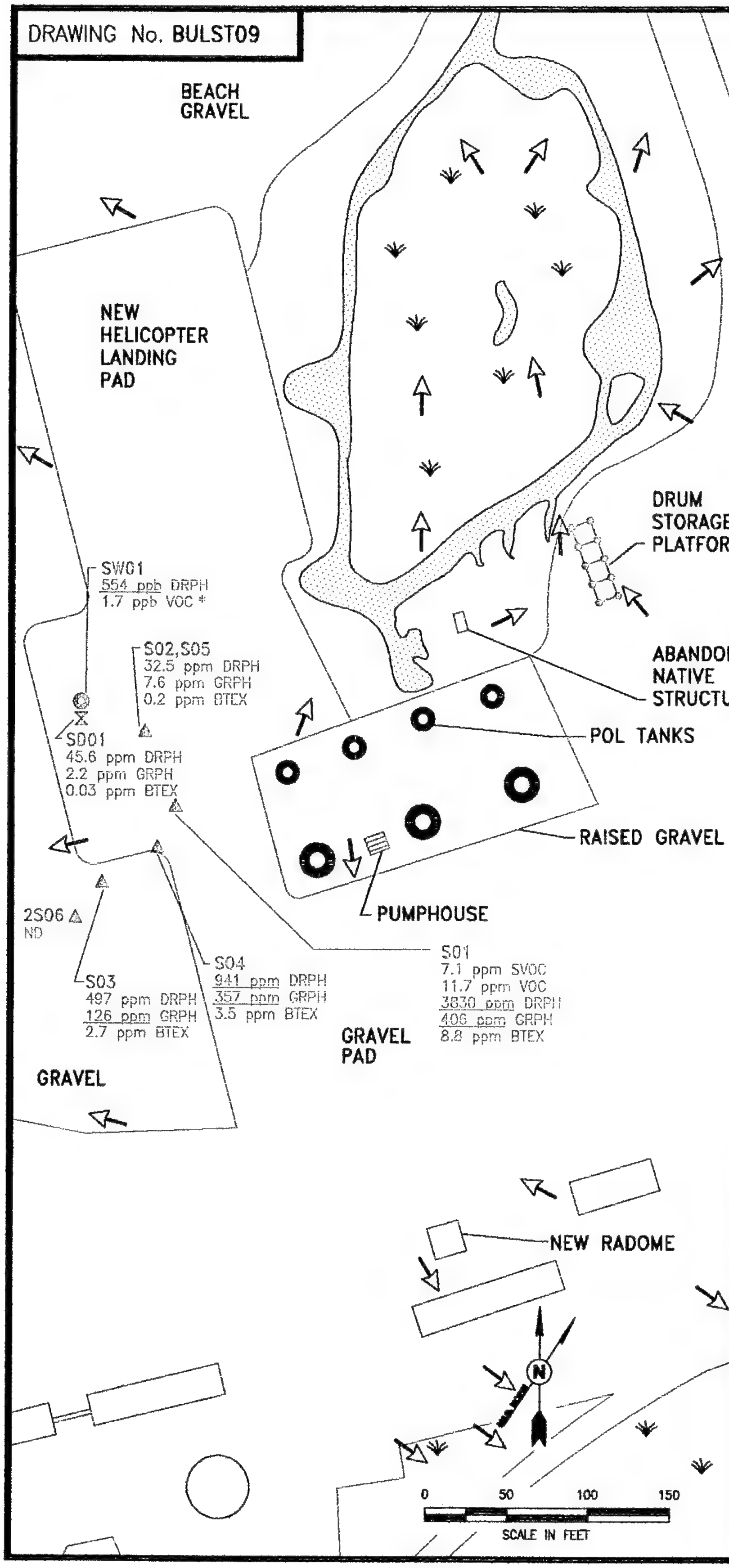

BULLEN POINT RADAR INSTALLATION

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FIGURE NO. 2-5

FUEL STORAGE AREA (ST09) SAMPLE LOCATIONS AND ANALYTICAL RESULTS

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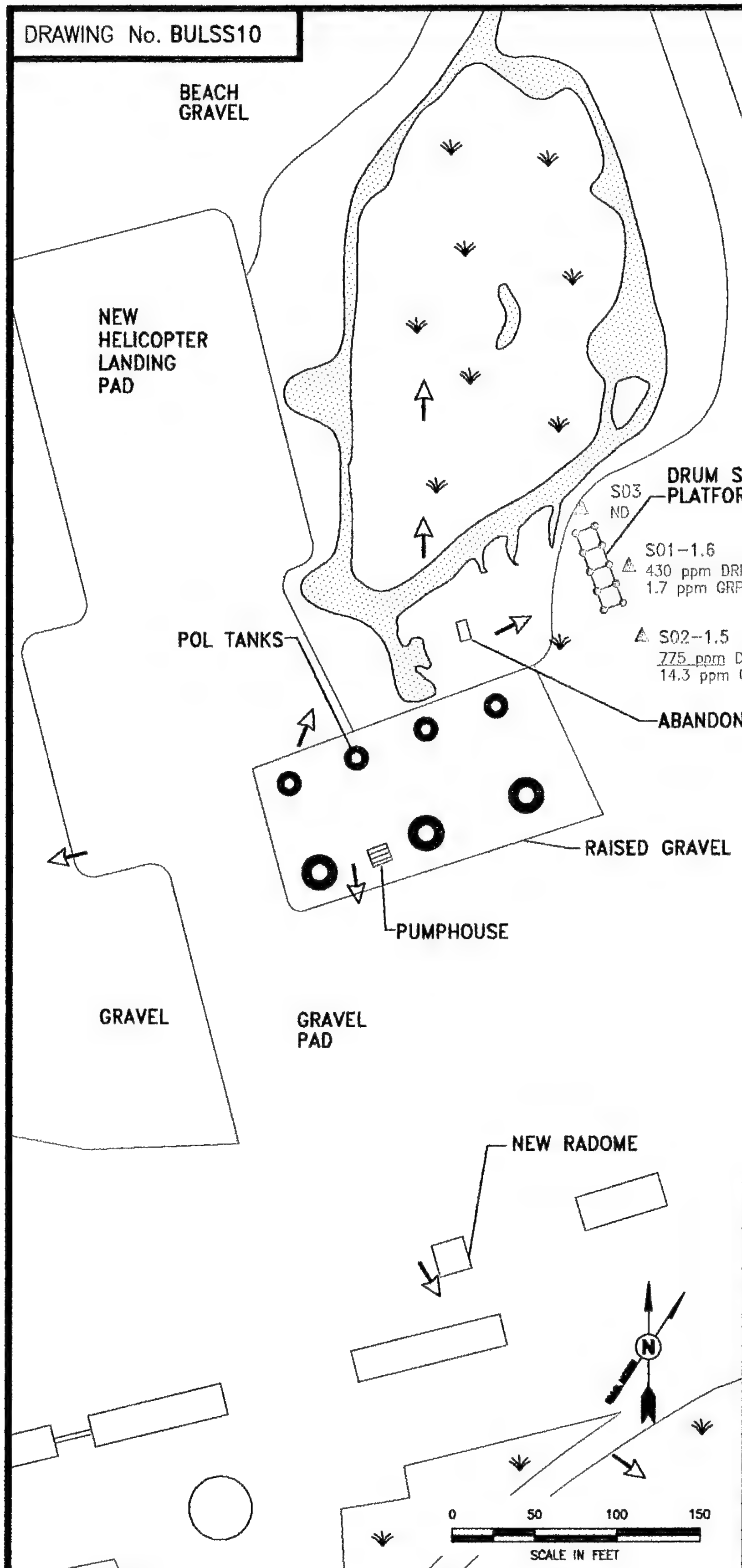

BULLEN POINT RADAR INSTALLATION

USAF 611th CES

FIGURE NO. 2-6

DRUM STORAGE AREA (SS10) SAMPLE LOCATIONS AND ANALYTICAL RESULTS

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2.1.5.6 Summary of Contaminants of Concern. A summary of the COCs identified for the soil/sediment and surface water for each site at Bullen Point is presented in Table 2-3. The COCs in this table will be used to quantify the noncancer hazard and the excess lifetime cancer risk in Section 2.4, Risk Characterization.

Table 2-3 contains a summary of the COCs identified for each site.

2.2 EXPOSURE ASSESSMENT

The exposure assessment section of a baseline human health risk assessment identifies and describes potential receptors and the exposure pathways by which exposure may occur, and estimates the magnitude of those exposures. This section includes an analysis of which pathways are complete (Section 2.2.1), migration and fate of COCs (Section 2.2.2), an estimation of the total intake of the chemicals (Section 2.2.3), and a summary of how the average daily dose (ADD) was calculated (Section 2.2.4).

2.2.1 Pathway Analysis

Pathway analysis involves the evaluation of the components of potential exposure pathways and a determination of whether each pathway is complete. An exposure pathway describes the course a chemical will take from a source to an exposure point where a receptor can come into contact with it. A complete exposure pathway has five components:

- source of contamination;
- release mechanism;
- transport mechanism;
- exposure point; and
- receptor.

If one component of an exposure pathway is missing, then exposure will not occur, and there is no health risk. For example, if a shallow aquifer was contaminated with tetrachloroethene but that aquifer was not used as a water supply, no exposure point would exist, and a ground water ingestion pathway would not be complete.

The potential exposure pathways evaluated for the Bullen Point human health risk assessment are presented in Figure 2-7 and Table 2-4, and are discussed in Sections 2.2.1.1 through 2.2.1.4.

2.2.1.1 Soil and Sediment Ingestion. Bullen Point installation workers and residents of the North Slope Borough may be exposed to soil and sediment contaminated by previous operations at the installation. The most likely exposure routes are incidental ingestion of soil and dermal absorption of contaminants in the soil. Site-specific characteristics will limit the magnitude, frequency, and duration of exposures to soil and sediment. The ground is covered with snow and ice, which eliminate soil or sediment exposure, for approximately nine months of the year. In the summer months when snow cover is generally absent, cool temperatures (30°F to 46°F) (University of Alaska 1978) keep both workers and villagers in heavy, long-sleeved

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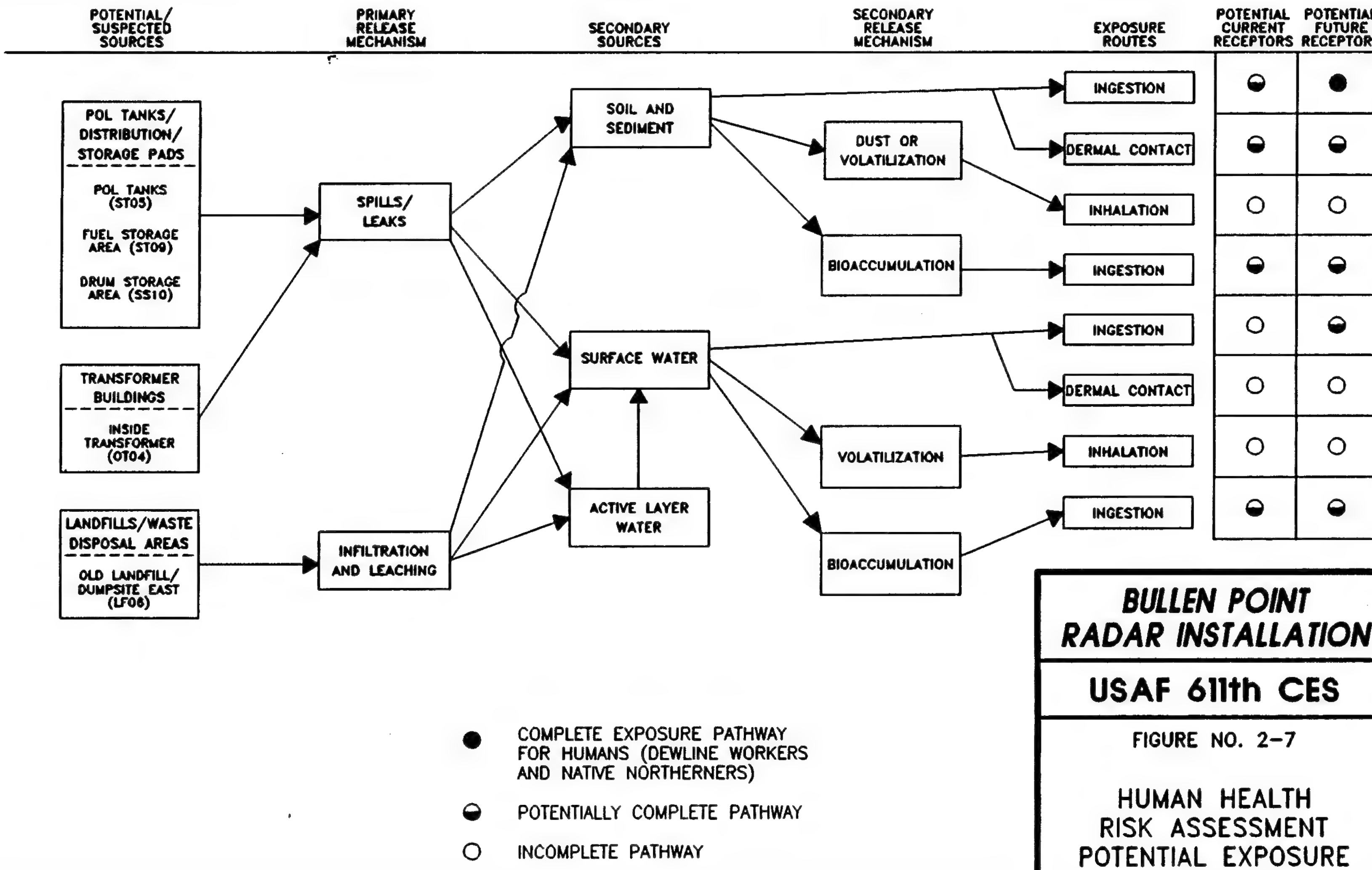

BULLEN POINT RADAR INSTALLATION

USAF 611th CES

FIGURE NO. 2–7

HUMAN HEALTH RISK ASSESSMENT POTENTIAL EXPOSURE PATHWAYS

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TABLE 2-4. EXPOSURE PATHWAY ANALYSIS FOR BULLEN POINT HUMAN HEALTH RISK ASSESSMENT

POTENTIALLY CONTAMINATED MEDIUM	POTENTIAL ROUTES OF EXPOSURE	POTENTIAL RECEPTORS	PATHWAY COMPLETE?	EXPOSED POPULATION ESTIMATE
Soil	Ingestion, dermal absorption	DEW Line workers, native community residents	Ingestion, Yes Dermal Contact, No	100[a]
Sediments	Ingestion, dermal absorption	DEW Line workers, native community residents	Ingestion, Yes Dermal Contact, No	100[a]
Air	Inhalation of volatiles from soil or surface water or inhalation of fugitive dust	DEW Line workers, native community residents	No, volatile concentrations in soil and surface water are very low; dust generation is not likely due to marshy vegetated landscape and high humidity; and snow and ice cover most of the year.	0
Surface Water	Incidental ingestion, dermal absorption	DEW Line workers, native community residents	Maybe, site surface water could be used under a future use scenario; when active the installation received drinking water upgradient of installation; fishing occurs in unaffected areas; swimming does not occur onsite, however, incidental exposure may occur during installation operations or trespassing by native villagers.	100[a]
Ground Water	Ingestion, dermal absorption	DEW Line workers, native community residents	No, permafrost limits presence of ground water to shallow active layer that is not used for any purpose.	0

[a] Assumes future residential land use. Currently this installation is unmanned, and there is no nearby village. The exposed population of 100 is an estimate of the size of a village that might exist at Bullen Point if the installation was ever released for residential use.

clothing and gloves that eliminate dermal contact with and hand-to-mouth transfer of soil. Therefore, although both the incidental soil ingestion and dermal contact pathways are unlikely to be complete, the incidental ingestion of soil or sediment will be evaluated further in this risk assessment in order to provide conservative estimates of risk.

The exposure assumptions used to evaluate the soil and sediment ingestion pathway are upper-bound residential scenario assumptions and, therefore, probably overestimate the true hazard or risk associated with this pathway. The purpose of using residential assumptions is to evaluate the hazard or risk associated with future residential use of the Bullen Point installation. Although the Bullen Point radar installation is presently operating as an unmanned short range radar system, it is possible that the installation may be retired and released for civilian use, in which case residential use of the installation may occur.

2.2.1.2 Inhalation. Bullen Point installation workers and native northerners may be exposed to site contamination by inhalation of organic compounds volatilized from the soil or surface water, or windborne dust to which contamination has adsorbed. These exposure pathways are not considered complete for the Bullen Point Risk Assessment because snow and ice cover the site for approximately nine months of the year, and during the summer months, the high humidity, vegetative cover, and thawing of surface and active layer water significantly limit the entrainment of dust particles in ambient air. The generally low temperatures and high moisture content of the soil also tend to inhibit volatilization. The inhalation pathway will not be considered further in this risk assessment.

2.2.1.3 Water Ingestion. Surface water features, particularly those potentially contaminated by operations at the installation, are not likely to be used for drinking or other domestic purposes even on an incidental basis. This is because these surface water features are not reliable, being frozen for most of the year. Ingestion of surface water will, however, be considered a potentially complete exposure pathway to reflect an upper bound potential risk under a future use scenario. Under current conditions, surface water at the installation is not used for domestic or other purposes. A fresh water supply for the area is not necessary given the unmanned operation of the installation.

2.2.1.4 Ground Water. Permafrost limits the presence of ground water to the active layer which thaws during the summer months. The water present in the active layer is not known to be used for any purpose; therefore, the ground water pathway will be eliminated from consideration in this risk assessment.

2.2.2 Migration and Fate of Chemicals of Concern

The COCs selected for Bullen Point generally fall into three classes:

- refined and residual petroleum hydrocarbons (DRPH and GRPH);
- volatile organic compounds (VOCs: benzene);
- polychlorinated biphenyls (PCBs: Aroclor 1254).

This section presents a summary of the migration and fate of each of these classes given the environmental conditions at Bullen Point.

Once released to the environment, the COCs are immediately subject to several processes, including evaporation and volatilization, bulk flow, soil adsorption, dissolution in surface or active layer water, biodegradation, and photooxidation. The extent to which the COCs undergo each of these processes depends on their chemical and physical properties (e.g., K_{OC}, K_{OW}, water solubility, vapor pressure, Henry's law constant), the volume released, soil flora, meteorological conditions, soil moisture, and organic carbon content.

The migration of petroleum hydrocarbons released to the gravel pads and tundra is expected to follow the rank order: GRPH > DRPH > RRPH. GRPH is generally considered to include hydrocarbons with carbon chain ranges from C5 to C12 that tend to be relatively mobile and less persistent than longer chain hydrocarbons. Depending on the length of time since a spill or leak occurred, the petroleum hydrocarbons observed in soil samples would be expected to be enriched in components that have carbon chain ranges greater than C10 or C11, have high K_{OC} and K_{OW} values, low vapor pressure and water solubility, and are not rapidly biodegradable. Petroleum components that fit this profile are higher molecular weight n-alkanes, mono- and poly-aromatics, and cycloalkanes. These components would tend to appear in laboratory analyses as diesel range or heavy oil range organics (DRPH and RRPH).

The migration of benzene is expected to be rapid compared to the petroleum hydrocarbons. VOCs tend to have high vapor pressures which favor volatilization, high water solubility, and low K_{OC} and K_{OW} values. Therefore, benzene would tend to be highly mobile in the environment and dissipate rapidly after a spill or leak. In the results of field sampling, benzene concentrations would be expected to be fairly low depending on the time since the spill or leak occurred. The frigid conditions on the North Slope, however, would tend to reduce the mobility due to volatilization or evaporation.

Polychlorinated biphenyls (PCBs), such as Aroclor 1254, are oily substances which would be expected to persist in the environment. In comparison to VOCs (e.g., benzene, tetrachloroethene, and vinyl chloride) which tend to be highly mobile and not persistent in the environment, PCBs have low K_{OW} values two to six orders of magnitude greater, K_{OC} values up to six orders of magnitude greater, and vapor pressure and water solubility values as much as six orders of magnitude less.

In conclusion, the COCs observed at the Bullen Point installation are generally expected to be fairly persistent and of low mobility. Exposure by contact with soils, primarily through accidental ingestion, is expected to predominate compared to exposure by inhalation.

2.2.3 Estimation of Chemical Intake

The exposure assessment for the Bullen Point DEW Line installation required the development of site-specific assumptions because of the unique location (no nearby villages) and unmanned operation of the installation. This section of the report focuses on the exposure variables for which site-specific assumptions were made. These variables include:

- exposure frequency;
- exposure duration;
- ingestion of locally produced meat (e.g., caribou, fish, and birds);
- ingestion of locally produced vegetation (e.g., berries);
- soil ingestion rate; and
- rate of dermal contact with soil.

The exposure assumptions used in the human health risk assessment are presented in Table 2-5.

Three potential receptor groups will be evaluated for the Bullen Point Risk Assessments: an adult assigned to maintenance work at the Bullen Point installation (DEW Line worker), an adult native of the North Slope of Alaska (native), and a native child (child). The native adult and child are considered to represent the reasonable maximum exposure that might occur at the installation under a future use scenario that includes residential receptors. Although there are no plans to do so, the Bullen Point installation may be released for civilian residential use in the future.

The estimation of chemical intake requires the evaluation of several exposure variables: exposure point concentration; exposure frequency; exposure duration; averaging time; ingestion of locally produced meat, fish, and vegetation; soil ingestion; drinking water ingestion; dermal contact with soil; inhalation; and body weight. These exposure variables are discussed in the following sections.

TABLE 2-5. EXPOSURE ASSUMPTIONS FOR ESTIMATING CHEMICAL INTAKE

PARAMETER	DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN CHILD
Exposure Frequency - Soil Ingestion (days/year)	14	30	30
Exposure Frequency - Water Ingestion (days/year)	14	180	N/A
Exposure Duration (years)	10	55[a]	6[a]
Soil Ingestion Rate (mg/day)	50	100	200
Drinking Water Ingestion Rate (L/day)	2	2	N/A
Average Body Weight (kg)	70	70	15
Averaging Time (days)	25,550 (cancer)[b] 3,650 (noncancer)[c,d]	25,550 (cancer)[b] 20,075 (noncancer)[c] 17,885 (noncancer)[d]	2,190 (noncancer)[d]

N/A Not applicable; drinking water pathway evaluated for adult only.

a Exposure duration for water ingestion pathway is 55 years. For soil ingestion, exposure duration is 6 years as a child and 49 years as an adult. Note: these assume a future use scenario.

b Averaging time for the evaluation of cancer risk by the soil and water ingestion pathways.

c Averaging time for the evaluation of noncancer hazard by the water ingestion pathway.

d Averaging time for the evaluation of noncancer hazard by the soil ingestion pathway.

2.2.3.1 Exposure Point Concentration. Based on the amount of analytical data available for the risk assessment of the Bullen Point installation, and the requirement that the risk characterization be conducted individually for each of the five sites, only maximum concentrations of the COCs were used for exposure point concentrations. This approach yields a conservative upper-bound estimate of the average daily dose (ADD) to which potential receptors may be exposed.

2.2.3.2 Exposure Frequency. The exposure frequency variable is an estimate of the amount of time a potential receptor may contact contaminated media. For the DEW Line worker, the exposure frequency estimate is based on the assumption that the radar installation will require two maintenance visits per year, with each visit lasting fourteen days. Based on the assumption that the maintenance visits will require 12-hour workdays, an estimated exposure frequency for DEW Line workers at the unmanned station would be 12 hours/day x 1 day/24 hours x 28 days/year = 14 days/year.

The soil ingestion exposure frequency estimate for a native adult or child of the North Slope is based on an estimate of the frequency with which the individual would be at a DEW Line installation involved in activities that include exposure to soil. In this case, a conservative estimate of exposure would be 4 hrs/day x 30 days per month x 1 day/24 hrs x 6 months of exposed soil per year = 30 days per year.

The exposure frequency for water ingestion was conservatively estimated at 180 days/year that surface water would be available (i.e., not frozen) and is based on a potential future scenario where site surface water is used as a drinking water source.

2.2.3.3 Exposure Duration. The exposure duration variable is an estimate of the amount of time a potential receptor will remain at or near a DEW Line installation over a lifetime. For the DEW Line worker the exposure duration is an estimate of the maximum tour of duty at an installation. A conservative estimate of the duration of a tour at a particular installation is 10 years. For the potential native receptor, a conservative estimate of exposure duration is 55 years based on the assumption that the site use will be residential. EPA's default reasonable maximum exposure duration is 30 years; however, this is based on the overall U.S. population. Because the Alaskan natives are more likely to remain in their village for a longer period, 55 years was determined to be a more appropriate estimate based on best professional judgement.

2.2.3.4 Averaging Time. The averaging time represents the period of time over which exposure is averaged and is based on the assumption that intermittent exposure at a given contaminant concentration is equivalent to a continuous exposure at a lower concentration. For the DEW Line worker, the averaging time is based on the EPA default lifetime of 70 years for evaluation of carcinogens, and 10 years (equivalent to the exposure duration) for the evaluation of noncarcinogens. For the native northern adults an averaging time of 70 years for carcinogens was also chosen. To evaluate exposure to noncarcinogens in soil and sediment for the native northern adult and child, an averaging time of 49 years as an adult and 6 years as a child was used (to account for 55 year total exposure). To evaluate the exposure of native northern receptors to noncarcinogens in water an averaging time of 55 years was used.

2.2.3.5 Ingestion of Locally Produced Meat, Fish, and Vegetation. The food supplies of DEW Line installation workers are largely imported from outside the area. Occasionally, a worker would be expected to ingest a locally caught fish or game animal, but the frequency and magnitude of this ingestion is expected to have a negligible effect on exposure to the COCs. Some reports indicate that, at least in parts of the North Slope Borough, the food supplies are imported from outside the area, and the reliance on hunting and fishing for subsistence is decreasing as the economy moves from subsistence to wage labor (Chance 1990). Other reports indicate that although Inupiats in general have less time to hunt and fish than in the past, 50 percent or more of their food may be derived from subsistence activities, and this level may be increasing (Harcharek 1994). Most hunting and fishing occurs away from the Bullen Point DEW Line installation in areas unaffected by the installation. It is not likely that contamination observed at the installation has affected the mammals, birds, and vegetation that may be collected for consumption. Therefore, the consumption of locally produced food is not likely to pose a significant risk of adverse health effects and will not be considered a complete exposure pathway. The ecological risk assessment, Section 3.0, presents a detailed assessment of risks to ecological receptors.

2.2.3.6 Soil Ingestion Rate. A conservative approach to estimating soil ingestion rate is to assume that the EPA default soil ingestion rate of 50 mg/day for workers (EPA 1991) and 100 mg/day for adults in a residential setting is applicable to the Bullen Point installation. The EPA default soil ingestion rate for children is 200 mg/day; this is the recommended value for the risk assessment.

2.2.3.7 Drinking Water Ingestion Rate. There are no circumstances at the Bullen Point installation that would invalidate the EPA default adult drinking water ingestion rate of 2 L/day. Therefore, this is the recommended value for both workers and natives. However in most, if not all, cases drinking water (when the installation was active) was imported from offsite, so this may not be a complete route of exposure.

By convention (EPA 1989a), noncancer hazard and cancer risk associated with the drinking water pathway are evaluated for an adult receptor, not a child (Table 2-5). The basis for this approach is that the ratio of drinking water ingestion rate to body weight is assumed to remain selectively constant from childhood to adulthood.

2.2.3.8 Dermal Contact with Soil Rate. Because of the harsh North Slope weather, potential receptors (both workers and natives) are expected to be heavily clothed and gloved. Observations made by RI field personnel indicate that potential human receptors were heavily clothed during the months of the field investigations (August and September 1993). Therefore, dermal exposure to contaminated soils is considered negligible. In addition, the duties of installation workers that involve soil work (excavating, grading, etc.) are conducted in equipment with enclosed cabs. Thus, a dermal contact rate does not appear to be necessary for the exposure assessment.

2.2.3.9 Inhalation Rate. The inhalation pathway is not complete (Section 2.2.1.2), so no estimate for this variable is necessary.

2.2.3.10 Body Weight. There are no circumstances at the Bullen Point installation that would invalidate the EPA default adult body weight of 70 kg. Therefore, this is the recommended value for both workers and natives. The recommended body weight for children is the EPA default value of 15 kg.

2.2.4 Quantifying Exposure

For each complete, or potentially complete, exposure pathway at the Bullen Point installation (soils ingestion, drinking water ingestion), the ADD for estimating noncancer hazard and the lifetime average daily dose (LADD) for estimating excess lifetime cancer risk were calculated. The equations used for the calculation of ADD and LADD are presented in Table 2-5.

The exposure assumptions assigned to each variable in these equations are presented in Table 2-5. The estimates of ADD and LADD for the COCs at each site are presented in the risk characterization spreadsheets in Appendix A.

2.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood or severity of adverse effects or both. This is done separately for noncarcinogenic effects (Section 2.3.1) and carcinogenic effects (Section 2.3.2). Toxicity summaries are presented in Section 2.3.3.

Toxicity assessment for environmental contaminants is generally accomplished in two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining whether exposure to an agent can cause an increase in the incidence of a particular adverse health effect (e.g., cancer, birth defects) and whether the adverse health effect is likely to occur in humans. Hazard identification involves characterizing the nature and strength of the evidence of causation. Dose-response evaluation is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population. From this quantitative dose-response relationship, toxicity values (e.g., reference doses and SFs) are derived that can be used to estimate the incidence or potential for adverse effects as a function of human exposure to the agent. These toxicity values are used in the risk characterization step to estimate the likelihood of adverse effects occurring in humans at particular exposure levels.

2.3.1 Toxicity Assessment for Noncarcinogenic Effects

A reference dose, or RfD, is the toxicity value used most often in evaluating noncarcinogenic effects resulting from exposures at contaminated sites. Various RfDs are available depending on the exposure route (oral or inhalation), the critical effect (developmental or other), and the length of exposure being evaluated (chronic, subchronic, or single event). The oral RfDs used

TABLE 2-6. EQUATIONS USED FOR ESTIMATING POTENTIAL DOSE

EXPOSURE ROUTE	EQUATION	PARAMETER DEFINITIONS
Ingestion of Soil	Native Northern Adults/Children $ADD \text{ or } LADD \ (mg/kg/day) = \frac{C_s * CF * EF}{AT} \sum_{i=1}^{n} \frac{IR_i * ED_i}{BW_i}$ DEW Line workers: $ADD \text{ or } LADD \ (mg/kg/day) = \frac{C_s * CF * IR * EF * ED}{BW * AT}$	C_s = concentration in soil (mg/kg) CF = conversion factor (10^{-6} kg/mg) IR = ingestion rate (mg/day) EF = exposure frequency (days/year) ED = exposure duration (years) BW = body weight (kg) AT = averaging time (days/year x years)
Ingestion of Surface Water	$ADD \text{ or } LADD \ (mg/kg/day) = \frac{C_w * CF * IR * EF * ED}{BW * AT}$	C_w = concentration in surface water (µg/L) CF = conversion faction (10^{-3} mg/µg) IR = ingestion rate (L/day) EF = exposure frequency (days/year) ED = exposure duration (years) BW = body weight (kg) AT = averaging time (days/year x years)

to estimate the noncancer hazard associated with exposure to soils, sediments, and surface water at the Bullen Point facility are presented in Table 2-7.

A chronic RfD is defined as an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs are developed specifically to be protective for long-term exposure to a compound. Chronic RfDs generally should be used to evaluate the potential noncancerous effects associated with exposure periods between 7 years (approximately 10 percent of a human lifetime) and a lifetime. Many chronic RfDs have been reviewed and verified by an intra-agency RfD workgroup and entered into EPA's IRIS database.

2.3.1.1 Concept of Threshold. For many noncancerous effects, protective mechanisms are believed to exist. These must be overcome before the adverse effect is manifested. For example, where a large number of cells perform the same or similar function, the cell population may have to be significantly depleted before the adverse effect is seen. As a result, a range of exposures from zero to some finite level exists that can be tolerated by the organism with essentially no chance of expression of adverse effects. In developing a toxicity value for evaluating noncancerous effects (i.e., an RfD), the approach is to identify the upper bound of this tolerance range (i.e., the maximum subthreshold level). Because variability exists among humans, attempts are made to identify a subthreshold level that protects sensitive individuals in the population. For most chemicals, this level can only be estimated; the RfD incorporates uncertainty factors (UFs) indicating the degree of extrapolation used to derive the estimated value. RfD summaries in IRIS also contain a statement expressing the overall confidence that the evaluators have in the RfD (high, medium, or low). The RfD is generally considered to have uncertainty spanning an order of magnitude or more, so the RfD should not be viewed as a strict scientific demarcation between levels that are toxic and nontoxic.

2.3.2 Toxicity Assessment For Carcinogenic Effects

A SF and the accompanying WOE determination are the toxicity data most commonly used to evaluate potential human carcinogenic risks. The methods EPA uses to derive these values are outlined below. Additional information can be obtained by consulting EPA's *Guidelines for Carcinogen Risk Assessment* (EPA 1986a) and IRIS Background Document #2 (IRIS 1994). The SFs for the COCs at Bullen Point are presented in Table 2-8.

2.3.2.1 Concept of Nonthreshold Effects. Risk evaluation, based on presumption of a threshold, is generally thought to be inappropriate for carcinogenesis. For carcinogens, EPA assumes that a small number of molecular events can evoke changes in a single cell and lead to uncontrolled cellular proliferation and eventually to a clinical state of disease. This hypothesized mechanism for carcinogenesis is referred to as "nonthreshold" because all levels of exposure pose a finite probability, however small, of generating a carcinogenic response. That is, no dose is thought to be risk-free, and an effect threshold cannot be estimated.

For carcinogenic effects, EPA uses a two-part evaluation in which the substance first is assigned a WOE classification, and then a SF is calculated.

TABLE 2-7. TOXICITY CRITERIA FOR NONCANCER EFFECTS OF THE CHEMICALS OF CONCERN FOR BULLEN POINT

CHEMICAL	ORAL REFERENCE DOSE (RfD) (mg/kg-day)	TARGET ORGAN OR CRITICAL EFFECT (species)[a]	UNCERTAINTY FACTOR[b]	ORAL RfD SOURCE[c]
Benzene	NA	NA	NA	IRIS
DRPH	0.08[d]	liver effects (mice)	10,000	ECAO
GRPH	0.2[d]	decreased body weight (rats)	1,000	ECAO
Aroclor 1254	0.00002	ocular exudate, inflamed Meibomian glands, distorted nail growth, immunosuppression (monkey)	300	IRIS

a A target organ is the organ apparently most sensitive to the toxicity of a chemical. A critical effect is reported when EPA has not identified a target organ for the toxicity of a given chemical.

b The uncertainty factors used to develop oral reference doses are generally applied in multiples of 10 to account for shortcomings in the toxicological database. The greater the uncertainty factor, the lower the confidence level on the RfD. A factor of 10 is applied to account for each of the following: human variability in toxic response, extrapolation from animal studies to humans, extrapolation of short-term exposures to long-term exposures, and for the extrapolation of a lowest-observed adverse effect level (LOAEL) to a no observed adverse effect level (NOAEL).

c Sources of oral RfD values are IRIS (Integrated Risk Information System), HEAST (Health Effects Assessment Summary Tables), or ECAO (The Environmental Criteria and Assessment Office of EPA).

d Oral RfD values for DRPH and GRPH are based on (EPA 1992c) and are considered provisional RfDs.

NA Not available.

TABLE 2-8. TOXICITY VALUES FOR THE CARCINOGENICITY OF THE CHEMICALS OF CONCERN AT BULLEN POINT

CHEMICAL	WEIGHT-OF-EVIDENCE (WOE)	TUMOR TYPE (species)	ORAL SLOPE FACTOR (kg-day/mg)	ORAL SLOPE FACTOR SOURCE[a]
Benzene	A	leukemia (human)	0.029	IRIS
DRPH	NA	NA	NA	NA
GRPH	C	liver adenoma/carcinoma (mouse)	0.0017	ECAO
Aroclor 1254 (PCB)	B2	trabecular carcinoma/adenocarcinoma, neoplastic nodule	7.7	IRIS

a IRIS, Integrated Risk Information System; ECAO, Environmental Criteria and Assessment Office of EPA.
NA Not available.

2.3.2.2 Assigning a Weight-of-Evidence. In the first step of the evaluation, the carcinogenicity data are evaluated to determine the likelihood that the agent is a human carcinogen. The evidence is characterized separately for human studies and animal studies as sufficient, limited, inadequate, no data, or evidence of no effect. The characterizations of these two types of data are combined, and based on the extent to which the agent has been shown to be a carcinogen in experimental animals or humans, or both, the agent is given a provisional WOE classification. EPA scientists then adjust the provisional classification upward or downward based on other supporting evidence of carcinogenicity.

The EPA classification system for WOE is shown in Table 2-9.

2.3.2.3 Generating a Slope Factor. For chemicals classified as known or probable human carcinogens, a toxicity value that defines quantitatively the relationship between dose and response (i.e., the slope factor) is calculated. Slope factors (SFs) are typically calculated for potential carcinogens in classes A, B1, and B2. Quantitative estimation of SFs for the chemicals in class C is done on a case-by-case basis.

Generally, the SF is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The SF is used in risk assessments to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. SFs should always be accompanied by the weight-of-evidence classification to indicate the strength of the evidence that the agent is a human carcinogen.

2.3.2.4 Identifying the Appropriate Data Set. In deriving SFs, the available information about a chemical is evaluated and an appropriate data set is selected; human data of high quality are preferable to animal data. If animal data are used, the species that responds most similarly to humans (with respect to factors such as metabolism, physiology, and pharmacokinetics) is preferred. When no clear choice is possible, the most sensitive species is given the greatest emphasis. Occasionally, in situations where no single study is judged most appropriate yet several studies collectively support the estimate, the geometric mean of estimates from all studies may be adopted as the SF. This practice ensures the inclusion of all relevant data.

2.3.2.5 Extrapolating to Lower Doses. Because risk at low exposure levels is difficult to measure directly either by animal experiments or by epidemiologic studies, the development of a SF generally entails applying a model to the available data set and using the model to extrapolate from the relatively high doses administered to experimental animals (or the exposures noted in epidemiologic studies) to the lower exposure levels expected for human contact in the environment.

A number of mathematical models and procedures have been developed to extrapolate from carcinogenic responses observed at high doses to responses expected at low doses. Different extrapolation methods may provide a reasonable fit to the observed data but may lead to large differences in the projected risk at low dose.

TABLE 2-9. EPA WEIGHT-OF-EVIDENCE CLASSIFICATION SYSTEM FOR CARCINOGENICITY

GROUP	DESCRIPTION
A	Human carcinogen.
B1 or B2	Probable human carcinogen.
	B1 indicates that limited human data are available.
	B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
C	Possible human carcinogen.
D	Not classifiable as to human carcinogenicity.
E	Evidence of noncarcinogenicity for humans.

In general, after the data are fit to the appropriate model, the upper 95th percent confidence limit of the slope of the resulting dose-response curve is calculated. This value is known as the SF and represents an upper 95th percent confidence limit of the probability of a response per unit intake of a chemical over a lifetime (i.e., there is only a 5 percent chance that the probability of a response could be greater than the estimated value on the basis of the experimental data and model used). In some cases, SFs based on human dose-response data are based on the "best" estimate instead of the upper 95th percent confidence limits. Because the dose-response curve generally is linear only in the low-dose region, the SF estimate only holds true for low doses. Information concerning the limitations on use of SFs can be found in IRIS.

2.3.2.6 Summary of Dose-Response Parameters. Toxicity values for carcinogenic effects can be expressed in several ways. The SF generally is considered to be the upper 95th percent confidence limit of the slope of the dose-response curve and is expressed as (mg/kg-day)$^{-1}$. Thus:

$$\text{Slope factor} = \text{risk per unit dose}$$
$$= \text{risk per mg/kg-day}$$

Where data permit, SFs listed in IRIS are based on absorbed doses, although many of them have been based on administered doses.

2.3.3 Summaries of the Toxicity of the Contaminants of Concern

Tables 2-7 and 2-8 present chronic cancer and noncancer health effects criteria (oral SFs and RfDs respectively) for the COCs. The toxicological properties of the COCs and the toxicological basis of the health effects criteria listed in Tables 2-7 and 2-8 are discussed in Appendix B.

2.4 RISK CHARACTERIZATION

In the risk characterization, the toxicity and exposure assessments are summarized and integrated into quantitative and qualitative expressions of risk. To characterize potential noncancerous effects, comparisons are made between projected intakes (ADD) of substances and toxicity values (e.g., the reference dose). To characterize potential carcinogenic effects, probabilities that an individual will develop cancer over a lifetime of exposure are estimated from projected intakes (LADD) and chemical-specific dose-response information (e.g., the SF). Major assumptions, scientific judgements and to the extent possible, estimates of the uncertainties embodied in the assessment are also presented. In this section methods of quantifying risks are discussed and applied to individual sites at the Bullen Point installation.

2.4.1 Quantifying Risks

This section describes the steps for quantifying risk or hazard indices for both carcinogenic and noncancerous effects to be applied to each exposure pathway analyzed. The first two subsections cover procedures for individual substances and are followed by a subsection on procedures for quantifying risks associated with simultaneous exposures to several substances.

2.4.1.1 Risks from Individual Substances - Carcinogenic Effects. For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen (i.e., incremental or excess individual lifetime cancer risk). The guidelines provided in this section are consistent with EPA (1986b). For some carcinogens, there may be sufficient information on mechanism of action that a modification of the approach outlined below is warranted. Alternative approaches may be considered in consultation with ECAO on a case-by-case basis.

The SF is used to convert estimated daily intakes, averaged over a lifetime of exposure, directly to incremental risk of an individual developing cancer. Because relatively low intakes (compared to those experienced by test animals) are most likely from environmental exposures, it generally can be assumed that the dose-response relationship will be linear in the low-dose portion of the multistage model dose-response curve. Under this assumption the SF is a constant, and risk will be directly related to intake. Thus, the linear form of the carcinogenic risk equation is usually applicable for estimating cancer risks. This linear low-dose equation is described below.

LINEAR LOW-DOSE CANCER RISK EQUATION

$$\text{Risk} = \text{LADD} \times \text{SF}$$

where:

Risk = a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer;

LADD = lifetime average daily dose averaged over 70 years (mg/kg-day); and

SF = slope factor, expressed in $(\text{mg/kg-day})^{-1}$.

Because the SF is often an upper 95th percentile confidence limit of the probability of response based on experimental animal data used in the multistage model, the carcinogenic risk estimate generally will be an upper-bound estimate. This means that the "true risk" will probably not exceed the risk estimate derived through use of this model and is likely to be lower than predicted.

2.4.1.2 Noncancer Hazards from Individual Substances - Noncancerous Effects. The measure used to describe the potential for noncancerous toxicity in an individual is not expressed as the probability of an individual suffering an adverse effect. EPA does not at the present time use a probabilistic approach to estimate the potential for noncancerous health effects. Instead, the potential for noncancerous effects is evaluated by comparing an exposure level over a specified time period (e.g., some fraction of a lifetime) with a reference dose derived for a similar exposure period. This ratio of exposure to toxicity is called a hazard quotient (HQ).

The noncancer HQ assumes there is a level of exposure (i.e., the RfD) below which it is unlikely even for sensitive populations to experience adverse health effects. If the exposure level (ADD) exceeds this threshold (i.e., if ADD/RfD exceeds unity), there may be concern for potential noncancer effects. As a rule, the greater the value of ADD/RfD above unity, the greater the level of concern. Ratios of ADD/RfD should not be interpreted as statistical probabilities; a ratio of 0.001 does not mean that there is a one in one thousand chance of the effect occurring. Further, it is important to emphasize that the level of concern does not increase linearly as the RfD is approached or exceeded because RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects. Thus, the slopes of the dose-response curve in excess of the RfD can range widely depending on the substance.

NONCANCER HAZARD QUOTIENT

Noncancer Hazard Quotient = ADD/RfD

where:

ADD = average daily dose (or intake);

RfD = reference dose

ADD and RfD are expressed in the same units and represent the same exposure period (e.g., chronic, subchronic, or short-term).

2.4.1.3 Aggregate Risks for Multiple Substances. Estimating risk or hazard potential by considering one chemical at a time might significantly underestimate the risks associated with simultaneous exposures to several substances. To assess the overall potential for cancer and noncancer effects posed by multiple chemicals, EPA has developed *Guidelines for the Health Risk Assessment of Chemical Mixtures* (EPA 1986b). These guidelines can be applied to simultaneous exposures to several chemicals from a variety of sources by more than one exposure pathway. Information on specific mixtures is rarely available. Even if such data exist, they are often difficult to use. Monitoring for "mixtures" or modeling the movement of mixtures across space and time presents significant technical problems given the likelihood that individual components will behave differently in the environment (i.e., fate and transport).

Although the calculation procedures differ for carcinogenic and noncarcinogenic effects, both sets of procedures assume dose additivity in the absence of information on specific mixtures.

Carcinogenic Effects. The cancer risk equation described below is used to estimate the incremental individual lifetime cancer risk for simultaneous exposure to several carcinogens based on EPA's risk assessment guidelines. This equation represents an approximation of the precise equation for combining risks that accounts for the joint probabilities of the same individual developing cancer as a consequence of exposure to two or more carcinogens. The difference between the precise equation and the approximation described in the equation below is negligible for total cancer risks less than 0.1. Thus, the simple additive equation is appropriate for most risk assessments.

CANCER RISK EQUATION FOR MULTIPLE SUBSTANCES

$$Risk_T = \Sigma\, Risk_i$$

where:

$Risk_T$ = the total cancer risk, expressed as a unitless probability; and

$Risk_i$ = the risk estimate for the i^{th} substance.

The risk summation techniques described in the cancer risk equation above assume that intakes of individual substances are small. They also assume independence of action by the compounds involved (i.e., there are no synergistic or antagonistic chemical interactions and all chemicals produce the same effect, i.e., cancer). If these assumptions are incorrect, over- or under-estimation of the actual multiple-substance risk could result.

A separate total cancer risk for each exposure pathway is calculated by summing the substance-specific cancer risks. Resulting cancer risk estimates should be expressed using one significant figure only.

There are several limitations to this approach. First, because each SF is an upper 95th percentile estimate of potency and upper 95th percentiles of probability distributions are not strictly additive, the total cancer risk estimate might become artificially more conservative as risks from a number of different carcinogens are summed. If one or two carcinogens drive the risk, however, this problem is not of concern. Second, it often will be the case that substances with different weights of evidence for human carcinogenicity are included. The cancer risk equation for multiple substances sums all carcinogens equally, giving as much weight to class B or C as to class A carcinogens. In addition, SFs derived from animal data will be given the same weight as SFs derived from human data. Finally, the action of two different carcinogens might not be independent.

Noncancerous Effects. To assess the overall potential for noncancerous effects posed by more than one chemical, a hazard index approach has been developed based on EPA's *Guidelines for Health Risk Assessment of Chemical Mixtures* (EPA 1986b). This approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum

of the ratios of the subthreshold exposures. The hazard index (HI) is equal to the sum of the HQs. When the hazard index exceeds unity, there may be concern for potential health effects. Any single chemical with an exposure level greater than the toxicity value will cause the hazard index to exceed unity and, for multiple chemical exposures, the hazard index can exceed unity even if no single chemical exposure exceeds its RfD. The equation used to determine noncancer hazard index is as follows:

NONCANCER HAZARD INDEX

$$\text{Hazard Index} = ADD_1/RfD_1 + ADD_2/RfD_2 + \ldots + ADD_i/RfD_i$$

where:

ADD_i = average daily dose (or intake) for the i^{th} toxicant;

RfD_i = reference dose for the i^{th} toxicant; and

ADD and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or shorter-term).

Where appropriate, a separate chronic hazard index can be calculated from the ratios of the chronic daily intake (CDI) to the chronic RfD for individual chemicals as described below.

CHRONIC NONCANCER HAZARD INDEX

$$\text{Chronic Hazard Index} = LADD_1/RfD_1 + LADD_2/RfD_2 + \ldots + LADD_i/RfD_i$$

where:

$LADD_i$ = lifetime average daily dose for the i^{th} toxicant in mg/kg-day, and

RfD_i = chronic reference dose for the i^{th} toxicant in mg/kg-day.

There are several limitations to this approach. As mentioned earlier, the level of concern does not increase linearly as the reference dose is approached or exceeded because the RfDs do not have equal accuracy or precision and are not based on the same severity of effect. Moreover, HQs are combined for substances with RfDs based on critical effects of varying toxicological significance. It will often be the case that RfDs of varying levels of confidence with different uncertainty adjustments and modifying factors will be combined (e.g., extrapolation from animals to humans, from LOAELs to NOAELs, and from one exposure duration to another).

Another limitation with the hazard index approach is that the assumption of dose additivity is most properly applied to compounds that induce the same effect by the same mechanism of action. Consequently, application of the hazard index equation to a number of compounds not expected to induce the same type of effects or that do not act by the same mechanism could overestimate the potential for effects, although such an approach is appropriate at a screening level. This possibility is generally not of concern if only one or two substances are responsible for driving the hazard index above unity. If the hazard index is greater than unity as a consequence of summing several HQs of similar value, it is appropriate to segregate the

compounds by effect and by mechanism of action and derive separate hazard indices for each group.

2.4.2 Site-Specific Risk Characterization

Soil and Sediment Exposures. The quantification of noncancer hazard and excess lifetime cancer risk associated with the soil ingestion pathway at Bullen Point was based on analytical data from soil and sediment samples collected within the interval from ground surface to permafrost. No attempt was made to segregate surface soil samples from subsurface samples in the human health risk characterization.

The noncancer hazard and the excess lifetime cancer risk associated with the ingestion of soil or sediment containing COCs has been estimated for a hypothetical native northerner based on six years of exposure as a child and 49 years of exposure as an adult. For the DEW Line worker, cancer risk has been estimated based on ten years of exposure averaged over a default lifetime of 70 years. Noncancer hazard for the DEW Line worker was based on a 10 year exposure.

Surface Water Exposures. The noncancer hazard and the excess lifetime cancer risk associated with the ingestion of surface water containing COCs has been estimated based on a native northern adult and a DEW Line worker. A native northern child receptor was not considered because, unlike exposure to soil, which is expected to be greater in a child than in an adult, the ratio of drinking water ingestion rate to body weight is assumed to be relatively constant from childhood to adulthood. A greater number of years is spent as an adult, so estimating hazard or risk for water ingestion based on an adult is a more conservative approach. The exposure duration estimate for the DEW Line worker was 10 years and for the native northern adult was 55 years. Exposures were averaged over 10 years for DEW Line worker exposure to noncarcinogens, and 55 years for native northern adult exposure to noncarcinogens. Exposures were averaged over 70 years for both receptor groups to characterize the risk associated with exposure to carcinogens in surface water.

Ingestion of surface water at the Bullen Point installation is not considered to be a complete pathway under a current use scenario. The installation was automated for unmanned operation and it is not located near a North Slope Borough community. Under a future use scenario, however, it is possible that the buildings could be used for residences or additional residential structures could be erected at the installation. The future residents could be either DEW Line workers or native northerners. Therefore, because sources of water may change in the future, potential ingestion of surface water at the installation will be evaluated for the DEW Line worker and native northern adult under a future use exposure scenario only.

Table 2-10 contains a site-by-site summary of the COCs in each medium, and the noncancer hazard and excess lifetime cancer risk associated with exposure to the COCs in the soils, sediments, and surface water. COCs without toxicity data (RBSLs or ARARs) are not included on Table 2-10, but are discussed in Section 2.1.5. Appendix A contains the spreadsheets used to calculate the noncancer hazard and excess lifetime cancer risk estimates presented in Table 2-10.

TABLE 2-10. SUMMARY OF NONCANCER HAZARD AND EXCESS LIFETIME CANCER RISK FOR BULLEN POINT

SITE	MEDIUM	NONCANCER CHEMICALS OF CONCERN[a]	NONCANCER HAZARD INDEX[c]			CARCINOGENIC CHEMICALS OF CONCERN[a]	EXCESS LIFETIME CANCER RISK[d]		
			DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD		DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD
Inside Transformer (OT04)	Soil	Aroclor 1254	0.001	—[e]	0.06	PCBs	3×10^{-8}	—[e]	**1×10^{-6}**
	Surface Water	NONE[b]	—	—	—	NONE	—	—	—
POL Tanks (ST05)	Soil	DRPH GRPH	0.002	—[e]	0.09	GRPH	1×10^{-9}	—	5×10^{-8}
	Surface water	DRPH GRPH	0.008	0.1	—[f]	GRPH Benzene	2×10^{-7}	**1×10^{-5}**	—[f]
Old Landfill/Dump Site East (LF06)	Soil	NONE	—	—	—	NONE	—	—	—
	Surface Water	DRPH	0.03	0.3	—	NONE	—	—	—
Fuel Storage Area (ST09)	Soil	DRPH GRPH	0.001	—	0.06	GRPH	3×10^{-9}	—	1×10^{-7}
	Surface Water	DRPH	0.008	0.1	—	NONE	—	—	—
Drum Storage Area (SS10)	Soil	DRPH	<0.001	—	0.01	NONE	—	—	—
	Surface Water	NONE	—	—	—	NONE	—	—	—

--- Not determined based on lack of contaminants of concern.

Bold Bold type indicates that the value presented exceeds a regulatory benchmark for noncancer hazard (1.0) or excess lifetime cancer risk (1×10^{-6}).

a All COCs are listed together regardless of whether they contribute to the hazard index, cancer risk, or both.

b None, no COCs selected.

c Hazard index, noncancer hazard index. The hazard index is the sum of the HQs for all of the COCs associated with a given medium, pathway, and receptor group.

d Cancer risk, excess lifetime cancer risk. The cancer risk is the sum of the excess lifetime cancer risks for all of the carcinogenic COCs associated with a given medium, pathway, and receptor group.

e Children are assumed to have a soil ingestion rate greater than that for adults. Therefore, under a residential scenario, the estimates of noncancer hazard and cancer risk associated with soil ingestion are estimated for a combined adult and child receptor only. This estimate is considered a conservative upper bound on the true hazard or risk.

f Drinking water ingestion, unlike soil ingestion, is evaluated for an adult receptor but not a child receptor because adults are assumed to have a longer exposure duration at a greater water ingestion rate. Therefore, the hazard or risk estimated will represent an upper bound, conservative estimate. For soil ingestion, the child soil ingestion rate is assumed to exceed that for adults. Therefore, a combination of the adult and child receptor groups is used to evaluate soil ingestion risk and hazard.

Risk Characterization of Petroleum Hydrocarbons. Petroleum hydrocarbons represent a primary source of contamination at the Bullen Point installation. The laboratory analysis of soil, sediment, and surface water samples revealed the presence of DRPH and GRPH. To characterize the risk associated with exposure to these compounds, we applied the provisional RfDs and the SF developed by EPA for petroleum hydrocarbons (EPA 1992d). These provisional RfDs provide the best available tool for characterizing the risk associated with exposure to the petroleum hydrocarbons. The RfD for JP-4 presented in EPA (1992d) was used to represent DRPH, and the RfD and SF for unleaded gasoline were used to represent GRPH.

The noncancer hazard associated with exposure to DRPH and GRPH was estimated by dividing the compound- and site-specific ADD by the appropriate provisional RfD (EPA 1992c). The excess lifetime cancer risk associated with exposure to GRPH was estimated by multiplying the compound- and site-specific LADD by the SF for unleaded gasoline (EPA 1992c).

Although the provisional RfDs and SF represent the best available numerical estimate of toxicity, there is a significant amount of uncertainty associated with their use at the Bullen Point installation. The RfDs and SF are based on studies in mice and rats by the inhalation route of exposure; whereas in this risk assessment, exposure of humans by the ingestion route is being evaluated. Furthermore, in the absence of a more thorough study to compare the DRPH and GRPH to known petroleum refinery streams, it is not clear how well the provisional values represent the toxicity of diesel and gasoline in humans.

Risk Characterization of Chemicals Detected. Chemicals detected above background levels without RBSLs or ARARs are evaluated in Section 2.1.5 (page 2-15). Based on the information in that section, and the relatively low levels detected at the sites, these chemicals are not expected to pose a health risk. Risk characterization of chemicals detected that exceed RBSLs, ARARs, or both are discussed on a site-by-site basis below.

2.4.2.1 Inside Transformer (OT04).

Soils and Sediments. The noncancer hazard associated with the ingestion of soil at the Inside Transformer (OT04) by a hypothetical native northern adult/child is 0.06 and by a DEW Line worker is 0.001, based on the maximum concentrations of Aroclor 1254 (Table 2-10 and A-1). The presence of Aroclor 1254 accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

The excess lifetime cancer risk associated with the ingestion of soil at the site by a hypothetical native northern adult/child is 1×10^{-6}, and by a DEW Line worker is 3×10^{-8}, based on the maximum concentration of Aroclor 1254 (Table 2-10 and A-2). The presence of Aroclor 1254 accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations.

Surface Water. No surface water bodies were identified at the site; therefore, no evaluation of noncancer hazard or excess lifetime cancer risk associated with ingestion of surface water was conducted.

2.4.2.2 POL Tanks (ST05).

Soils and Sediments. The noncancer hazard associated with the ingestion of soil at POL Tanks (ST05) by a hypothetical native northern adult/child is 0.09, and by a DEW Line worker is 0.002, based on the maximum concentrations of the COCs (Table 2-10 and A-3). The presence of DRPH and GRPH accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

The excess lifetime cancer risk associated with the ingestion of soil at the site by a hypothetical native northern adult/child is 5×10^{-8}, and by a DEW Line worker is 1×10^{-9}, based on the maximum concentrations of the COCs (Table 2-10 and A-4). The presence of GRPH accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations.

Surface Water. The noncancer hazard associated with the ingestion of surface water at the site by a hypothetical native northern adult is 0.1, and by a DEW Line worker is 0.008, based on the maximum concentrations of DRPH and GRPH (Table 2-10 and A-5). The presence of DRPH and GRPH accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

The excess lifetime cancer risk associated with the ingestion of surface water at the site by a hypothetical native northern adult is 1×10^{-5}, and by a DEW Line worker is 2×10^{-7}, based on the maximum concentration of the COCs (Table A-6). The presence of GRPH and benzene accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations.

2.4.2.3 Old Landfill/Dump Site East (LF06).

Soils and Sediments. No COCs were identified for the soil/sediment at the Old Landfill/Dump Site East (LF06) (Table 2-10). This does not indicate that exposure to chemicals in the soil at the site is without health risk; however, the concentrations measured were lower than the concentrations considered acceptable under Region 10 guidance (EPA 1991a) or federal ARARs.

Surface Water. The noncancer hazard associated with the ingestion of surface water at the site by a hypothetical native northern adult is 0.3, and by a DEW Line worker is 0.03, based on the maximum concentration of DRPH (Table 2-10 and A-7). The presence of DRPH accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

No carcinogenic COCs were identified for the surface water at the site; therefore, the excess lifetime cancer risk associated with ingestion of surface water cannot be quantified.

2.4.2.4 Fuel Storage Area (ST09).

Soils and Sediments. The noncancer hazard associated with the ingestion of soil at the Fuel Storage Area (ST09) by a hypothetical native northern adult/child is 0.06, and by a DEW Line worker is 0.001, based on the maximum concentrations of the COCs (Table 2-10 and A-8). The

presence of DRPH and GRPH accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

The excess lifetime cancer risk associated with the ingestion of soil at the site by a hypothetical native northern adult/child is 1×10^{-7}, and by a DEW Line worker is 3×10^{-9}, based on the maximum concentration of GRPH (Table 2-10 and A-9). The presence of GRPH accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations.

Surface Water. The noncancer hazard associated with the ingestion of surface water at the site by a hypothetical native northern adult is 0.1, and by a DEW Line worker is less than 0.008, based on the maximum concentration of DRPH (Table 2-10 and A-10). The presence of DRPH accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

No carcinogenic COCs were identified for the surface water at the site; therefore, the excess lifetime cancer risk associated with ingestion of surface water cannot be quantified.

2.4.2.5 Drum Storage Area (SS10).

Soils and Sediments. The noncancer hazard associated with the ingestion of soil at the Drum Storage Area (SS10) by a hypothetical native northern adult/child is 0.01, and by a DEW Line worker is less than 0.001, based on the maximum concentration DRPH (Table 2-10 and A-11). The presence of DRPH accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

No carcinogenic COCs were identified for the soils or sediments at the site; therefore, the excess lifetime cancer risk associated with ingestion of soils or sediments cannot be quantified.

Surface Water. No COCs were identified for the surface water at the site (Table 2-10). This does not indicate that exposure to chemicals in the surface water at the site is without health risk; however, the concentrations measured were lower than the concentrations considered acceptable under Region 10 guidance (EPA 1991a) or federal ARARs.

2.5 RISK CHARACTERIZATION UNCERTAINTY

Several sources of uncertainty affect the estimates of excess lifetime cancer risk and noncancer hazard as presented in this risk assessment. The sources are generally associated with:

- Sampling and analysis of soil, sediment, and surface water;
- Assigning the source of contamination;
- Exposure assumptions, including estimates of exposure point concentrations;
- Evaluation of the toxicity of the COCs; and

- Methods and assumptions used to characterize the cancer risk and noncancer hazard.

Uncertainties associated with sampling and analyses include the inherent variability (standard error) in the analyses, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. The quality assurance/quality control program used in conducting the sampling and analyses serves to reduce errors, but it can not eliminate all errors associated with sampling and analyses. There is some uncertainty in the selection of COCs with respect to sample quantitation limits for a given chemical. In some cases a chemical may have had detected values below the COC screening criteria as well as samples with quantitation limits greater than the screening criteria. In these cases it should be understood that only the samples with adequate quantitation limits are applicable to the screening process. Thus, the number of samples used to screen a chemical would be less than the total number of analyses for that chemical.

Simplifying assumptions were made about the environmental fate and transport of the site contamination, specifically, that no contaminant loss or transformation occurs. Thus, the data chosen to represent exposure point concentrations in the sample-by-sample risk calculations are an additional source of potential error.

The depth at which a soil sample was collected was not considered in the risk characterization, so exposure to subsurface contamination was considered to be equally likely as exposure to surface contamination. This approach would tend to overestimate the true risk.

The estimation of exposure requires many assumptions to describe potential exposure situations. There are uncertainties regarding the likelihood of exposure, frequency of contact with contaminated media, the concentration of contaminants at exposure points, and the time period of exposure. These tend to simplify and approximate actual site conditions. In general, these assumptions are intended to be conservative and yield an overestimate of the true risk or hazard.

The toxicological database is also a source of uncertainty. The EPA has outlined some of the sources of uncertainty in the database (EPA 1986a,b, 1989a). These sources include extrapolation between exposure routes, from high to low doses, and from animals to humans; species, gender, age, and strain differences in uptake, metabolism, organ distribution, and target site susceptibility; and human population variability with respect to diet, environment, activity patterns, and cultural factors. The toxicity factors from IRIS and HEAST, which are used to estimate the toxicity of the COCs, are developed using a highly conservative methodology and probably tend to overestimate the potential hazards to humans.

Use of the provisional RfDs and SFs for DRPH and GRPH, is an additional source of uncertainty in the toxicity assessment and risk characterization. Although the provisional RfDs represent the best available numerical estimate of toxicity, there is a significant amount of uncertainty associated with their use at the Bullen Point installation. The RfDs and SFs are based on studies in mice and rats by the inhalation route of exposure; whereas, in this risk assessment, exposure of humans by the ingestion route only is being evaluated. Furthermore, in the absence of more thorough studies to compare the toxicity of DRPH and GRPH to the toxicity of known refinery

streams, it is not clear how well the provisional values represent the toxicity of diesel and gasoline in humans.

In the risk characterization, the assumption was made that the total risk of developing cancer from exposure to site contaminants is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancer adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach does not account for the possibility that chemicals act synergistically or antagonistically but probably results in an overestimate of the true risk.

In addition to the more general sources of uncertainty associated with risk assessment methodology, there are site-specific sources of uncertainty. Primarily, these sources are associated with the lifestyle of the native northerners, the time spent on the sites that were investigated during the RI, and specific exposure assumptions (soil ingestion rate, exposure frequency, and exposure duration).

Residents of the North Slope Borough may use the installation as an access route to natural hunting and fishing locations (Brewster 1994). No studies have been conducted to measure the time they spend on contaminated sites at the installation. Some of the sites with levels of contamination that exceed regulatory benchmarks are not likely to be accessed by this group [e.g., Inside Transformer (OT04)]. Therefore, the assumptions made regarding exposure frequency probably result in an overestimate of the true noncancer hazard and cancer risk.

Similarly, no studies have been conducted to measure the soil ingestion rate of potential receptors on the contaminated sites. Soil ingestion by potential future inhabitants at Bullen Point (assuming a potential residential scenario) may be greater than the default rate of 100 mg/day for adults and 200 mg/day for children. Given the rugged, partially subsistence, lifestyle of this group, it is possible that they incidentally ingest soil at a higher rate than receptors of a similar age in the continental United States. The estimate of soil ingestion rate used in this risk assessment may over- or underestimate the true rate.

The maximum exposure duration assumed for native northerners, 55 years, is probably fairly accurate. The reasonable maximum exposure estimate for inhabitants of the continental United States is 30 years; however, native northerners are more likely to remain in their villages for a longer period. Although, the exposure duration of 55 years is an estimate, it is not expected to significantly over- or underestimate hazard or risk.

2.6 RISK ASSESSMENT SUMMARY AND CONCLUSIONS

The human health risks associated with exposure to contaminated media (soil, sediment, or surface water) at five sites at the Bullen Point radar installation were evaluated in this risk assessment. The risk assessment was developed using a three step process:

1) The maximum concentrations of the chemicals detected in each medium (soil, sediment, or surface water) were compared to background concentrations, RBSLs,

and ARARs. Chemicals present at concentrations that exceeded their background concentration and either an RBSL or an ARAR were retained as COCs for the risk assessment.

2) In the risk characterization, the noncancer HQ, the excess lifetime cancer risk, or both were calculated based on the maximum concentration of each COC and its associated toxicity value developed by EPA.

3) The HQs for each COC at a given site were summed and the sum (called a Hazard Index or HI) was compared to the regulatory benchmark for noncancer hazard: an HI of 1. Sites where the hazard index exceeded 1 were considered to warrant either remediation or further discussion. Sites where the hazard index was less than 1 are considered to warrant no further action (EPA 1991c).

   The cancer risks for each carcinogenic COC at a given site were also summed and the sum (the total cancer risk) was compared to the regulatory benchmark for cancer risks: an excess lifetime cancer risk of 1×10^{-6} (one in one million). Sites where the total cancer risk exceeded 1×10^{-6} are considered for further discussion (EPA 1991c). Sites where the total cancer risk was less than 1×10^{-6} are considered to warrant no further action.

Table 2-11 contains a summary of the noncancer hazard and excess lifetime cancer risk for each site and medium at the Bullen Point installation that exceeds a regulatory benchmark of 1.0 for noncancer hazard index or 1×10^{-6} for excess lifetime cancer risk.

No Further Action. Three of the five sites are considered to warrant no further action because no chemical detected at these sites was classified as a COC or the noncancer hazard index and the excess lifetime cancer risk are below the regulatory benchmarks of 1.0 for the hazard index and 1×10^{-6} for cancer risk. These sites are the Old Landfill/Dump Site East (LF06), Fuel Storage Area (ST09), and Drum Storage Area (SS10) (Table 2-10).

Sites that Warrant Further Discussion. The presence of GRPH in the surface water at the POL Tanks (ST05) yields a cancer risk of 1×10^{-5} for the drinking water ingestion pathway. Because this installation is not manned, there are no nearby villages, and the surface water at the site is not a source of drinking water, this cancer risk estimate grossly overestimates the true cancer risk. In addition, a cancer risk of 1×10^{-5} falls within the range of cancer risks (1×10^{-6} to 1×10^{-4}) that EPA considers to not warrant remediation (EPA 1991c). Given the remote location of the installation, the unmanned operation, and that the surface water at the site is not used for any purpose, it does not appear that remediation of the GRPH in the surface water is warrented.

The presence of Aroclor 1254 in the soil at the Inside Transformer (OT04) site accounts entirely for the cancer risk at this location (Table 2-10). The cancer risk, however, was based on the cancer SF for the PCB family. The specific carcinogenicity of Aroclor 1254 has not been evaluated by the EPA; therefore, a WOE classification has not been assigned nor has a cancer SF been developed. Evaluation of the toxicology literature for Aroclor 1254 revealed that there was a dose-related increase in hepatocellular carcinomas in rats and hepatomas in mice that

TABLE 2-11. SUMMARY OF SITES WITH CONTAMINATION THAT EXCEEDS REGULATORY BENCHMARKS
[Noncancer Hazard Index > 1.0, Excess Lifetime Cancer Risk > 1×10^{-6}]

SITE	MEDIUM	NONCANCER CHEMICALS OF CONCERN[a]	CARCINOGENIC CHEMICALS OF CONCERN	NONCANCER HAZARD INDEX			EXCESS LIFETIME CANCER RISK		
				DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD	DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD
POL Tanks (ST05)	Surface Water	DRPH GRPH	Benzene, GRPH	—	—	—	—	1×10^{-5}	—

[a] All COCs are listed regardless of whether they contribute to the hazard index or cancer risk.

received Aroclor 1254 for 2 years or 11 months, respectively. These studies, however, were conducted on small numbers of animals that received high doses of Aroclor 1254. Whether these studies may be extrapolated to humans requires more study. Thus, applying the PCB SF to Aroclor 1254 may over- or under-estimate the cancer risk for humans.

The excess lifetime cancer risk associated with potential exposure to the Aroclor 1254 at the Inside Transformer site is 1×10^{-6}. The estimation of this cancer risk was based on highly conservative exposure assumptions, including lifetime exposure of residential receptors. The Bullen Point installation is currently, and will continue to be, an unmanned installation. Furthermore, there is no nearby village (Deadhorse is located 40 miles to the west and no roads connect it to the installation). EPA does not generally require remediation at a site where the cancer risk falls within or below the 1×10^{-6} to 1×10^{-4} cancer risk range (EPA 1991c). Given the conservative assumptions applied to the estimation of cancer risk at this site, the true cancer risk is probably well below 1×10^{-6}. Thus, remediation of this site is not considered necessary.

In conclusion, based on the human health risk assessment, no further action appears to be warranted at the five sites investigated at the Bullen Point installation.

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3.0 ECOLOGICAL RISK ASSESSMENT

The objective of this ERA is to estimate potential impacts to aquatic and terrestrial plants and animals at the Bullen Point DEW Line installation based on sampling and analyses conducted during the RI of the five installation sites. The RI was completed during the summer of 1993 in conjunction with RIs at seven other radar installations.

Guidance documents used during preparation of this assessment include:

- Handbook to Support the Installation Restoration Program Statements of Work (U.S. Air Force 1991);
- Framework for Ecological Risk Assessment (EPA 1992a); and
- Ecological Risk Assessment Guidance for Superfund (EPA 1994a).

The approach used to assess potential ecological impacts is conceptually similar to that for human health risks. Potentially exposed populations (receptors) are identified, and then information on exposure and toxicity are combined to derive estimates of risk. The ERA focuses, however, on potential impacts to a population of organisms rather than individual organisms (except in the case of endangered species where individuals are considered). Because ecosystems are composed of a variety of species, ERAs evaluate potential impacts to numerous species.

Ideally, ERAs should evaluate potential risks to communities and ecosystems, as well as to individual populations. Because of the large number of species and communities present in natural systems, such ecosystem-wide assessments are very complex and appropriate assessment methodologies have not yet been developed. In addition, dose-response data on community or ecosystem responses generally are lacking. Therefore, evaluations of potential impacts to communities or ecosystems are qualitative.

The degree to which potential ecological impacts can be characterized is highly dependent upon the data available to support such estimates. Such data include: information regarding contaminant release, transport and fate of COCs, characteristics of potential receptor populations, and adequate supporting toxicity data for the chemicals evaluated.

This ERA is intended to be at a screening level, rather than a full scale investigation of the state of the ecosystem. No site-specific studies of the biota were undertaken. It is based on media sampling (i.e., surface water and soil/sediment samples), and it is divided into six sections:

Section 3.1 - Selection of Site Contaminants;
Section 3.2 - Ecological Exposure Assessment;
Section 3.3 - Ecological Toxicity Assessment;
Section 3.4 - Risk Characterization for Ecological Receptors;

Section 3.5 - Ecological Risk Assessment Uncertainty Analysis; and
Section 3.6 - Summary of Ecological Risk.

3.1 SELECTION OF SITE CONTAMINANTS

A stressor in the environment is a chemical, physical, or biological action that can cause a negative impact on an ecosystem (EPA 1992a). Only chemical stressors identified as COCs are evaluated as part of this ERA. A review of the site data indicates that the chemical stressors are primarily petroleum products, solvents, PCBs, and metals.

The five sites at the Bullen Point DEW Line installation are all considered to be potentially suitable habitat for ecological receptors because the installation has been inactive and/or unmanned since 1971 (the Inside Transformer site is evaluated using only the soil samples associated with the site). As a result, human activities that would discourage use by representative species are limited and not expected to deter species from frequenting the installation.

COCs are selected based on comparisons of maximum detected concentration to background concentrations and action levels [Federal Ambient Water Quality Criteria (AWQC) for surface water (EPA 1994); ADEC Water Quality Standards (18 AAC 70.020[b]) January 1995; Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota (Suter and Mabrey 1994); ADEC determination of cleanup levels for petroleum contaminated soils (Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, 17 July 1991); EPA sediment quality criteria (as estimated by Hull and Suter, 1994); and NOAA Sediment Effects Range (Low) (NOAA 1991)]. If no action levels were available, the maximum detected concentration of the chemical was compared to a toxicity value derived from acute or chronic exposure tests available in the literature. If the maximum concentration was above this level, the compound was considered a COC. Chemicals present onsite at concentrations in excess of background concentrations and action levels were evaluated for frequency of detection in onsite media. If a chemical was detected at a frequency of less than five percent, it was not considered representative of actual site conditions and was eliminated from evaluation in the risk assessment. Further, an attempt was made to eliminate elements that were within the range of natural background levels. If the average concentration (exposure concentration) of a chemical was below the maximum background concentration (i.e., if the average falls within the range of background), and if the maximum detected concentration was less than twice the maximum background concentration (which is meant to approximate the 95 percent UCL of background concentrations), the chemical was not considered a COC. Note that this criterium is used to account for outliers (i.e., hotspots) that are not representative of the distribution and concentration of chemicals to which ecological receptors may be exposed. Tables 3-1 and 3-2 present the data used in the screening process for surface water and soil/sediment. Only chemicals that were detected in at least one environmental sample are presented in these summary tables.

TABLE 3-1. SUMMARY OF CHEMICALS OF CONCERN: SURFACE WATER

CHEMICALS OF CONCERN: BULLEN POINT INSTALLATION SURFACE WATER						
CHEMICAL	RANGE OF DETECTED CONCENTRATIONS (μg/L)	BACKGROUND (μg/L) Organics: Bullen Point Inorganics: Seven DEW Line Stations	ACTION LEVEL (μg/L)	FREQUENCY OF DETECTION	AVERAGE CONCENTRATION FOR COC (μg/L)	SELECTED AS COC
ORGANICS						
DRPH[e]	298 - 1,870	<200	---	4/5	890	**YES**
Toluene	1.2	<1	17,500[a]	1/5	0.6	NO
Ethylbenzene	7.6	<1	32,000[a]	1/5	1.9	NO
Xylenes (total)	19.2	<2	62,308[b]	1/5	4.6	NO
1,2-Dichloroethane	1.7 - 2.6	1.9B - 4.5B	20,000[a]	2/2	2.15	NO
INORGANICS - based on total metals						
Aluminum	330	<100 - 350	87[c]	1/1	330	NO
Barium	67	<50 - 93	5,800[b]	1/1	67	NO
Calcium	49,000	4,500 - 88,000	116,000[b]	1/1	49,000	NO
Iron	2,900	180 - 2,800	1,000[c]	1/1	2,900	**YES**
Magnesium	18,000	<5,000 - 53,000	82,000[b]	1/1	18,000	NO
Manganese	78	<50 - 510	80.3[d]	1/1	78	NO
Sodium	72,000	8,400 - 410,000	680,000[b]	1/1	72,000	NO

--- Not Available.
a EPA Ambient Water Quality Criteria (AWQC). Value presented is the Lowest Observed Effect Level (LOEL).
b Based on the Lowest Chronic Value for All Organisms presented in Suter and Mabrey (1994).
c EPA Ambient Water Quality Criteria, fresh water chronic criteria.
d Based on the secondary chronic value presented in Suter and Mabrey (1994).
e Range of concentrations does not include DRPH concentrations detected in two subsurface water samples; see discussion in Section 3.1.1.

TABLE 3-2. SUMMARY OF CHEMICALS OF CONCERN: SOILS AND SEDIMENTS

CHEMICALS OF CONCERN: BULLEN POINT INSTALLATION SEDIMENT AND SOIL						
CHEMICAL	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	BACKGROUND RANGE (mg/kg)	ACTION LEVEL (mg/kg)	FREQUENCY OF DETECTION	AVERAGE CONCENTRATION FOR COC (mg/kg)	SELECTED AS COC
ORGANICS						
DRPH	6.01 - 3,830	<4.00 - 157	500[b]	28/35	370	**YES**
GRPH	0.701 - 406	<0.500 - 1.03	100[b]	13/35	39	**YES**
Benzene	0.031N - 0.035	<0.025 - <0.040	0.052[c]	2/32	0.01	NO
Toluene	0.029 - 0.533	<0.025 - <0.040	0.786[a]	8/32	0.04	NO
Ethylbenzene	0.049 - 1.570	<0.025 - <0.040	4.36[c]	9/32	0.16	NO
Xylenes (total)	0.028 - 6.630	<0.025 - <0.040	1.21[a]	10/32	0.67	**YES**
n-Butylbenzene	0.857J	<0.025 - <0.035	4.36[d]	1/5	0.19	NO
sec-Butylbenzene	0.303J	<0.025 - <0.035	0.786[e]	1/5	0.08	NO
Isopropylbenzene	0.170J	<0.025 - <0.035	4.36[d]	1/5	0.05	NO
p-Isopropyltoluene	0.581	<0.025 - <0.035	4.36[d]	1/5	0.13	NO
Naphthalene	4.37J	<0.025 - <0.035	0.34[a]	1/5	0.89	**YES**
n-Propylbenzene	0.259J	<0.025 - <0.035	4.36[d]	1/5	0.07	NO
1,2,4-Trimethylbenzene	0.072J - 2.710J	<0.025 - <0.035	4.36[d]	2/5	0.57	NO
1,3,5-Trimethylbenzene	0.025J - 0.848J	<0.025 - <0.035	4.36[d]	2/5	0.19	NO
2-Methylnaphthalene	3.320	<0.240 - <1.00	--	1/5	0.75	NO
di-n-Butylphthalate	0.534 - 0.740	<0.240 - <1.00	42.1[c]	3/5	0.41	NO
bis(2-ethylhexyl)phthalate	0.306 - 0.447	<0.240 - <1.00	890,000[a]	2/5	0.22	NO
4-Methylphenol	0.580	<0.240 - <1.00	--	1/5	0.21	**YES**
PCBs (Aroclor 1254)	0.47J - 0.9J	<0.020	0.17[c]	2/19	0.1	**YES**

TABLE 3-2. SUMMARY OF CHEMICALS OF CONCERN: SOILS AND SEDIMENTS (CONTINUED)

CHEMICALS OF CONCERN: BULLEN POINT INSTALLATION SEDIMENT AND SOIL						
CHEMICAL	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	BACKGROUND RANGE (mg/kg)	ACTION LEVEL (mg/kg)	FREQUENCY OF DETECTION	AVERAGE CONCENTRATION FOR COC (mg/kg)	SELECTED AS COC
INORGANICS						
Aluminum	1,400 - 11,000	1,500 - 25,000	--	4/4	4,100	NO
Barium	19 - 130	27 - 390	--	4/4	50	NO
Beryllium	3.8	<3.0 - <36	--	1/4	2	NO
Calcium	1,900J - 34,500	360 - 59,000	--	4/4	14,600	NO
Chromium	2.7 - 18	4.3 - 47	80[a]	4/4	11	NO
Copper	3.4 - 13	<2.7 - 45	70[a]	4/4	9	NO
Iron	4,300 - 15,000	5,400 - 35,000	--	4/4	8,400	NO
Lead	40	<5.1 - 22	35[a]	1/4	12	NO
Magnesium	1,100 - 3,000	360 - 7,400	--	4/4	1,900	NO
Manganese	45 - 76	25 - 290	--	4/4	61	NO
Nickel	4.7 - 16	4.2 - 46	30[a]	4/4	9	NO
Potassium	950	<300 - 2,200	--	1/3	400	NO
Sodium	52 - 690	<160 - 680	--	3/4	260	NO
Vanadium	4.1 - 28	6.3 - 59	--	4/4	12	NO
Zinc	14 - 34	9.2 - 95	120[a]	4/4	27	NO

-- Not available.
a NOAA 1991, sediment ER-L (Effects Range - low).
b ADEC, Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, 17 July 1991.
c EPA Sediment Quality Criteria (estimated using equilibrium partitioning approach summarized in Hull and Suter 1994).
d EPA Sediment Quality Criteria for ethylbenzene (see text).
e EPA Sediment Quality Criteria for toluene (see text).
J Estimated value.
N Presumptive evidence.

In summary, the decisions for selecting COCs were made using the following logic:

STEP ONE: Is the chemical detected above the maximum detected background concentration?

No: Not considered a COC.
Yes: Continue to step two.

STEP TWO: Is the chemical detected above the action level or toxicity value?

No: Not considered a COC.
Yes: Continue to step three.

STEP THREE: Is the chemical detected at a frequency greater than five percent?

No: Not considered a COC.
Yes: Continue to step four.

STEP FOUR: Is the average concentration of the chemical greater than the maximum background concentration, and is the maximum detected concentration greater than two times the maximum background concentration?

No: Not considered a COC.
Yes: Chemical is classified as a COC.

All data for COCs were averaged (arithmetic mean) according to media. In the case of non-detects, averages were calculated using one-half of the quantitation limits. Replicate samples were averaged and treated as one sample. Total metal concentrations were used in determining COCs in surface water. This is a conservative approach because dissolved metal concentrations (the more bioavailable fraction) can be significantly lower than total metal concentrations. Section 3.1.1 describes surface water COCs, and Section 3.1.2 describes soil and sediment COCs. Any exceptions to the selection methodology are discussed in these sections.

3.1.1 Surface Water

Analytical results from three sites (i.e., POL Tanks, Old Landfill/Dump Site East, and Fuel Storage Area) were compiled and evaluated to identify the COCs. Surface water samples were collected and analyzed for contaminants likely to be present at the specific sites. Not all samples were analyzed for a "full suite" of parameters, but instead were analyzed for some combination of the following: DRPH, GRPH, RRPH, BTEX, halogenated volatile organic compounds (HVOCs), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), PCBs, pesticides, and metals. The surface water replicate samples, SW01 and SW03 from the Old Landfill/Dump Site East, were the only water samples analyzed for inorganic chemicals (i.e., metals). Two active layer water samples (samples GW01 and GW02) collected from hand-augered boreholes in the gravel pad at the POL Tanks (ST05) were not considered in this ERA. Although analyses of these samples did confirm subsurface contamination, the collection method

likely introduced cross-contamination, and the results may not be indicative of the true levels of contamination. In addition, ecological receptors are very unlikely to come in contact with the subsurface water below the gravel pad areas.

A summary of analytical results for all sampling conducted at the installation is presented in Appendix G. The following sections present the evaluation of the surface water data. Table 3-1 summarizes evaluation and selection of COC's in surface water.

3.1.1.1 Organic Compounds. Five organic compounds were detected in surface water samples collected from the Bullen Point installation: DRPH, toluene, ethylbenzene, xylenes (total), and 1,2-dichloroethane. This section presents the evaluation of these compounds as COCs in surface water for the ERA.

DRPH were detected in four of five surface water samples collected at the Bullen Point installation. The range of detected concentrations was 298 to 1,870 μg/L. DRPH were not detected in background samples at a detection limit of 200 μg/L. The average concentration of DRPH at the Bullen Point installation was 890 μg/L. There is no established action level for DRPH. Because these concentrations exceeded the background level, DRPH were selected as a COC.

Toluene was detected in one of five surface water samples at a concentration of 1.2 μg/L. Toluene was not detected in background samples at a detection limit of 1 μg/L. Although the concentrations exceeded the background level, the detected concentration was well below the action level of 17,500 μg/L, and toluene was not considered a COC.

Ethylbenzene was detected in one of five surface water samples at a concentration of 7.6 μg/L. Ethylbenzene was not detected in background samples at a detection limit of 1 μg/L. The action level for ethylbenzene is 32,000 μg/L. Because the sample concentration did not exceed the action level, ethylbenzene was not selected as a COC.

Xylene was detected in one of five surface water samples at a concentration of 19.2 μg/L. This compares to a background non-detect level of <2 μg/L and an action level of 62,308 μg/L. Because the sampled concentration was below the action level, xylene was not selected as a COC.

1,2-Dichloroethane was detected in each of the two surface water samples at concentrations of 1.7 and 2.6 μg/L. 1,2-Dichloroethane was detected in background samples at concentrations ranging from 4.9 to 5.2 μg/L and was also detected in numerous associated blanks. The action level of this compound is 20,000 μg/L, based on AWQC lowest observed effect level (LOEL). Because 1,2-dichloroethane was detected at levels below background and action levels, it was not considered a COC.

3.1.1.2 Metals. Two surface water samples collected at the Bullen Point installation and were analyzed for metals. The samples were collected at the Old Landfill/Dump Site East as replicate samples at locations designated SW01 and SW03. Seven inorganic analytes were detected: aluminum, barium, calcium, iron, magnesium, manganese, and sodium. This section

presents the evaluation of these metals as COCs for the ERA. Analytes not detected in surface water samples were: antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, potassium, selenium, silver, thallium, vanadium, and zinc. The background ranges presented are representative of seven DEW Line installations. It is important to note that, in some cases, sample quantitation limits for certain metals were somewhat higher than ecologically relevant action levels. For example, in the case of copper, the sample quantitation limit was 50 μg/L. However, the current AWQC (based on a hardness value of 100 mg/L $CaCO_3$) for copper is 12 μg/L. As a result, an ecological risk may exist for aquatic organisms from exposure to certain metals at their sample quantitation limits. These metals include: cadmium, chromium, copper, lead, and selenium. These issues will be addressed further in Section 3.5, Uncertainty Analysis. All concentrations of metals discussed below are results from total metal analyses.

Aluminum was detected in surface water samples at an average concentration of 330 μg/L. Background concentrations ranged from <100 to 350 μg/L. The EPA chronic AWQC for aluminum is 87 μg/L; this value was used as the action level. Aluminum is not present in surface water at concentrations in excess of the maximum background level, so it was not selected as a COC.

Barium was detected in surface water samples at an average concentration of 67 μg/L. Background concentrations of barium ranged from <50 to 93 μg/L. The action level for barium is 5,800 μg/L, based on data presented in Suter and Mabrey (1994). The value selected as the action level is the Lowest Chronic Values for All Organisms. Barium was not selected as a COC because it did not exceed the maximum background level.

Calcium was detected in surface water samples at an average concentration of 49,000 μg/L. Background concentrations ranged from 4,500 to 88,000 μg/L. The action level is 116,000 μg/L based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994). Because calcium did not exceed background concentrations, it was not selected as a COC.

Iron was detected in surface water samples at an average concentration of 2,900 μg/L. Background concentrations ranged from 180 to 2,800 μg/L. Iron exceeded the background concentration in surface water and the 1,000 μg/L action level based on the AWQC, so it was retained as a COC. The exposure concentration evaluated in this ERA is the average concentration of 2,900 μg/L.

Magnesium was detected in surface water samples at an average concentration of 18,000 μg/L. Background concentrations ranged from <5,000 to 53,000 μg/L. There is no AWQC for magnesium. However, 82,000 μg/L may be used as a toxicological screening benchmark based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994). Magnesium was not retained as a COC because it was below background concentrations.

Manganese was detected in surface water samples at an average concentration of 78 μg/L. Background concentrations ranged from <50 to 510 μg/L. The action level for manganese is 80.3 μg/L based on the Secondary Chronic Value presented in Suter and Mabrey (1994). Because manganese did not exceed background levels, it was not selected as a COC.

Sodium was detected in surface water samples at an average concentration of 72,000 μg/L, which is within the range of background concentrations of 8,400 to 410,000 μg/L. The action level for sodium of 680,000 μg/L was based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994). Because sodium concentrations did not exceed the background levels, sodium was not selected as a COC.

3.1.2 Soils and Sediments

Soil/sediment sample analytical results from the five sites were compiled and evaluated to determine the COCs. Because most ecological receptors are principally exposed to surficial soils and sediments, only samples collected from 0 to 1.5 feet were considered in this ERA. Thirty-five of the fifty-seven samples collected from the installation are within this category (excluding three wipe samples from the floor of the "Inside Transformer" area that were only analyzed for PCBs). The soil/sediment samples that were screened from the evaluation ranged from two to six feet below the surface. Not all samples were analyzed for a "full suite" of parameters, but instead were analyzed for some combination of the following: DRPH, GRPH, RRPH, BTEX, HVOCs, VOCs, SVOCs, PCBs, pesticides, and metals. A summary of analytical results for all sampling conducted at the installation is presented in Appendix G. The following sections present the evaluation of the soil/sediment data for the five sites. Only compounds that were detected on the sites are discussed. Table 3-2 summarizes the evaluation and selection of COCs in soil/sediment.

3.1.2.1 Petroleum Hydrocarbons. Thirty-five surface soil/sediment samples were collected from the five sites and selectively analyzed for a combination of DRPH and GRPH. Four soil/sediment samples were collected and analyzed for RRPH. A discussion of these petroleum hydrocarbon mixtures and their toxicity is presented in Section 3.3.1.

DRPH were detected in 28 of 35 soil/sediment samples ranging from 6.01 to 3,830 mg/kg; these mixtures were not detected in background samples at detection limits of 4 to 157 mg/kg. The action level for DRPH in soils/sediments is 500 mg/kg. Because DRPH were detected onsite at levels above the action levels and above background, they were retained as a COC. The exposure concentration used in the risk assessment is the average concentration of 370 mg/kg.

GRPH were detected in 13 of 35 soil/sediment samples ranging from 0.701 to 406 mg/kg. The background concentrations ranged from <0.500 to 1.03 mg/kg. The action level for GRPH is 100 mg/kg. GRPH were detected at concentrations above the action level and above background, so they were considered a COC. The exposure concentration used in the risk assessment is the average concentration of 39 mg/kg.

RRPH were not detected in four samples at detection limits of 100 and 120 mg/kg, so RRPH were not considered a COC.

3.1.2.2 Benzene, Toluene, Ethylbenzene, and Xylenes. Thirty-two soil/sediment samples collected from the five sites at the Bullen Point installation were analyzed for BTEX by the 8020/8020 modified method. In addition, ethylbenzene, toluene, and xylenes were detected using the VOC (8260) analysis. In the case of these duplicate analyses, the average

concentration was calculated from the analytical method that produced the highest concentration. This is a conservative approach expected to be protective of ecological receptors. The following paragraphs summarize the analytical results.

Benzene was detected in 2 out of 32 soil/sediment samples at 0.031 and 0.035 mg/kg. Benzene was not detected in background samples (<0.025 - <0.040 mg/kg). The estimated action level for benzene is 0.052 mg/kg, based on the equilibrium partitioning approach presented in Hull and Suter (1994). Because concentrations of benzene onsite did not exceed the action level, benzene was not considered a COC.

Toluene was detected in 8 out of 32 soil/sediment samples ranging from 0.029 - 0.533 mg/kg. Toluene was not detected in background samples above quantitation limits of 0.025 to 0.040 mg/kg. The action level for this compound is 0.786 mg/kg. Because concentrations at the site did not exceed the action level, toluene was not considered a COC.

Ethylbenzene was detected in 9 of 32 soil/sediment samples at concentrations ranging from 0.049 to 1.570 mg/kg. Ethylbenzene was not detected in background samples above quantitation limits of 0.025 to 0.040 mg/kg for soil/sediment; the action level is 4.36 mg/kg based on the equilibrium partitioning approach presented in Hull and Suter (1994). Because onsite concentrations did not exceed action levels, ethylbenzene was not considered a COC.

Xylenes (total) were detected in 10 of 32 samples. Xylenes concentrations ranged from 0.028 to 6.630 mg/kg. Xylenes were not detected in background samples above quantitation limits of 0.025 to 0.040 mg/kg. The action level is 1.21 mg/kg. Xylenes were considered a COC because onsite concentrations were above action levels. The exposure concentration used in this ERA is the average concentration of 0.67 mg/kg.

3.1.2.3 Volatile Organic Compounds. Seven VOCs were detected in soil/sediment samples collected from the Bullen Point installation. The compounds detected were: n-butylbenzene, sec-butylbenzene, isopropylbenzene, p-isopropyltoluene, n-propylbenzene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene. None of these chemicals was detected in background samples (quantitation limits of 0.025 to 0.035 mg/kg). This section presents the evaluation of these compounds as COCs for the ERA.

n-Butylbenzene was detected in one of five soil/sediment samples at 0.857 mg/kg. The detected sample was collected from the Fuel Storage Area (ST09, sample S01). Because there are no action levels for this compound, a literature search was conducted to evaluate its toxicity. n-Butylbenzene ($C_{10}H_{14}$) is an alkylbenzene, which is a class of chemicals commonly found in diesel oil and gasoline [Agency for Toxic Substances and Disease Registry (ATSDR) 1993]. In order to evaluate the relative toxicity of n-butylbenzene, comparisons of the toxicity to other alkylbenzenes may be made (i.e., toluene, ethylbenzene).

Generally, as functional groups (e.g., methyl-, ethyl-, butyl-) are added to a benzene ring, the octanol water partition coefficient (K_{ow}), which controls the bioavailability of nonpolar organic compounds (Baudo et al. 1990), increases. In addition, as the number of functional groups increases, the toxicity of the chemical tends to increase. However, compounds with a large K_{ow}

are more tightly sorbed to sediments and thus less bioavailable. This decrease in bioavailability offsets the increase in toxicity. Thus, the sediment screening values also increase as functional groups are added and as K_{ow} increases. This trend may be observed in the sediment screening values: benzene: 0.052 mg/kg; toluene: 0.786 mg/kg; and ethylbenzene: 4.36 mg/kg (Hull and Suter 1994). The log K_{ow}s of benzene (2.13), toluene (2.69), and ethylbenzene (3.15) illustrate the direct relationship between the K_{ow}, toxicity, and the sediment screening values (see Table 3-3). Examining the K_{ow} of alkylbenzenes illustrates an important point: as K_{ow} increases, the expected toxicity in sediments declines. (Note: all physical/chemical properties presented in this section are derived from EPA 1992c).

The log K_{ow} of n-butylbenzene (4.2) is greater than that of ethylbenzene (3.15). Based on the trends exhibited above (i.e., the relationships between increasing functional groups, toxicity, and K_{ow}), it appears that n-butylbenzene may be expected to be less toxic than ethylbenzene. The action level for ethylbenzene in soil/sediment is 4.36 mg/kg. Because n-butylbenzene was detected well below this level (0.857 mg/kg), it was not considered a COC. Further, alkylbenzenes are constituents of fuel oils (i.e., DRPH) (ATSDR 1993). Because DRPH are a COC (detected at higher concentrations and at a higher frequency of detection) it is assumed that the evaluation of the toxicity of DRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

sec-Butylbenzene was detected in one of five soil/sediment samples at a concentration of 0.303 mg/kg (sample ST09-S01). There are no action levels available for this compound. However, sec-butylbenzene is an alkylbenzene, a class of chemicals commonly found in fuel oil (ATSDR 1993). The log K_{ow} for sec-butylbenzene is 4.24. Based on the information presented for n-butylbenzene (above), it appears that sec-butylbenzene may be expected to be less toxic than another alkylbenzene, toluene. The action level for toluene is 0.786 mg/kg. Because sec-butylbenzene was detected only once on site below the action level for a similar chemical, it is not considered a COC.

Isopropylbenzene was detected in one of five soil/sediment samples from the Bullen Point installation. This compound was found in sample S01 from the Fuel Storage Area (ST09) at a concentration of 0.170 mg/kg. There are no action levels available for this chemical. However,

TABLE 3-3. CHEMICAL/PHYSICAL PROPERTIES

CHEMICAL	LOG K_{ow} [a]	ESTIMATED SEDIMENT QUALITY CRITERIA (mg/kg) [b]
Benzene	2.13	0.052
Toluene	2.69	0.786
Ethylbenzene	3.15	4.36

[a] EPA 1992c.
[b] Hull and Suter 1994.

isopropylbenzene is an alkylbenzene; a class of chemicals commonly found in fuel oil (ATSDR 1993). The log K_{ow} of isopropylbenzene is 3.66. Based upon the discussion presented for n-butylbenzene (above), the toxicity of isopropylbenzene is likely to be less than that of ethylbenzene. The action level for ethylbenzene is 4.36 mg/kg. Because this compound was detected only once on site, below the action level for a similar chemical, it was not considered a COC.

p-Isopropyltoluene (also an alkylbenzene) was detected in one of five soil/sediment samples at a concentration of 0.581 mg/kg. This chemical was not detected in background samples at detection limits of 0.025 to 0.035 mg/kg. There are no action levels for this compound. The log K_{ow} of p-isopropyltoluene is 4.10. The log K_{ow} is greater than that of toluene and ethylbenzene. The action level for toluene is 0.786 mg/kg, and the action level for ethylbenzene is 4.36. The concentration of p-isopropyltoluene is below the action levels for both these alkylbenzenes. As a result, p-isopropyltoluene was not considered a COC.

Naphthalene was detected in one of five soil/sediment samples at a concentration of 4.37 mg/kg. This chemical was not detected in background samples at detection limits of 0.025 to 0.035 mg/kg. The action level for this compound is 0.34 mg/kg. It was retained as a COC, and the exposure concentration evaluated in this ERA is the average concentration of 0.89 mg/kg.

n-Propylbenzene was detected in one of five soil/sediment samples at a concentration of 0.259 mg/kg. This chemical was not detected in background samples at detection limits of 0.025 to 0.035 mg/kg. There are no action levels for this compound; it is an alkylbenzene, a class of chemicals commonly associated with fuel oils (ATSDR 1993). The log K_{ow} for n-propylbenzene is 3.68, greater than that of ethylbenzene. Based on the discussion presented for n-butylbenzene (above), this trend indicates that the expected toxicity of n-propylbenzene would be less than the toxicity of ethylbenzene. As a result, the action level for ethylbenzene provides a conservative benchmark against which n-propylbenzene concentrations may be compared. The concentration of n-propylbenzene was below the action level for ethylbenzene of 4.36. As a result, n-propylbenzene was not considered a COC.

1,2,4-Trimethylbenzene was detected in two of five soil/sediment samples at concentrations of 0.072 and 2.710 mg/kg. This compound was not detected in background samples at detection limits of 0.025 to 0.035. There is no action level for this compound. 1,2,4-Trimethylbenzene is classified as an alkylbenzene, with a log K_{ow} of 3.63 which is greater than that of ethylbenzene. Based on the discussion presented for n-butylbenzene (above), this indicates that the expected toxicity of 1,2,4-trimethylbenzene would be less than the toxicity of ethylbenzene. As a result, the action level for ethylbenzene provides a conservative benchmark against which 1,2,4-trimethylbenzene concentrations may be compared. The action level for ethylbenzene is 4.36 and the concentrations of 1,2,4-trimethylbenzene (0.072 and 2.71 mg/kg) were below this level. As a result, 1,2,4-trimethylbenzene was not considered a COC. Further, trimethylbenzenes (alkylbenzenes) are constituents of fuel oils (i.e., DRPH) (ATSDR 1993). Because DRPH are a COC (detected at higher concentrations and at a higher frequency of detection) it is assumed that the evaluation of the toxicity of DRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

1,3,5-Trimethylbenzene was detected in two of five samples at concentrations of 0.025 to 0.848 mg/kg. This compound was not detected in background samples at detection limits of 0.025 to 0.035 mg/kg. There is no action level for this compound. 1,3,5-Trimethylbenzene is also classified as an alkylbenzene, and its log K_{ow} is 3.42, greater than that of ethylbenzene. Based on the discussion presented for n-butylbenzene, this indicates that the expected toxicity of 1,3,5-trimethylbenzene would be less than the toxicity of ethylbenzene. As a result, the action level for ethylbenzene provides a conservative benchmark against which 1,3,5-trimethylbenzene concentrations may be compared. The action level for ethylbenzene is 4.36, and the maximum concentration of 1,3,5-trimethylbenzene was below this level. As a result, 1,3,5-trimethylbenzene was not considered a COC. Further, trimethylbenzenes (alkylbenzenes) are constituents of fuel oils (i.e., DRPH) (ATSDR 1993). Because DRPH are a COC (detected at higher concentrations and at a higher frequency of detection) it is assumed that the evaluation of the toxicity of DRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

3.1.2.4 Semivolatile Organic Compounds. Four semivolatile organic compounds were detected at the Bullen Point installation: 2-methylnaphthalene, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, and 4-methylphenol. These chemicals were not detected in background samples at detection limits ranging from 0.240 to 1.00 mg/kg.

2-Methylnaphthalene was detected in one of five soil/sediment samples collected from the Bullen Point installation. The concentration detected was 3.320 mg/kg. There are no action levels available for this compound. Naphthalenes are constituents of fuel oils (ATSDR 1993). As a result, it is assumed that the evaluation of the toxicity of DRPH (detected at higher concentrations and at a higher frequency) will conservatively account for the incremental risk associated with 2-methylnaphthalene (see Section 3.3.1).

di-n-Butylphthalate was detected in three out of five soil/sediment samples at concentrations ranging from 0.534 to 0.740 mg/kg. The action level for this compound is 42.1 mg/kg as estimated using the equilibrium partitioning approach presented in Hull and Suter (1994). Because onsite concentrations were below the action level, this compound was not considered a COC.

Bis(2-ethylhexyl)phthalate was detected in two out of five soil/sediment samples at concentrations ranging of 0.306 and 0.447 mg/kg. The action level for this compound is 890,000 mg/kg based on estimates presented in Hull and Suter (1994). Because onsite concentrations were well below action levels, this chemical was not considered a COC.

4-Methylphenol was detected in one of five soil/sediment samples at 0.580 mg/kg. This sample was collected from the landfill (sample LF06-SD01). There are no action levels for this chemical, and it is not a common constituent of fuel oils. Therefore, it was retained as a COC. The average concentration evaluated in this risk assessment is 0.21 mg/kg.

3.1.2.5 Polychlorinated Biphenyls. PCBs were detected in 2 of 19 soil/sediment samples collected from the Inside Transformer site (OT04). Concentrations were 0.47 and 0.9 mg/kg. The action level for the group of PCBs detected, Aroclor 1254, is 0.17 mg/kg based on EPA Sediment Quality Criteria (Hull and Suter 1994). Because concentrations onsite are in

excess of action levels, PCBs were retained as a COC. The average concentration evaluated in the risk assessment is 0.1 mg/kg.

3.1.2.6 Metals. Fifteen inorganic analytes were detected in four soil/sediment samples collected. The metals detected were: aluminum, barium, beryllium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. This section presents the evaluation of these metals as COCs for the ERA.

Aluminum was detected in all four soil/sediment samples. Concentrations ranged from 1,400 to 11,000 mg/kg. Background concentrations ranged from 1,500 to 25,000 mg/kg. There is no action level for aluminum. Onsite concentrations did not exceed background concentrations, so aluminum was not retained as a COC.

Barium was detected in all four soil/sediment samples at concentrations between 19 and 130 mg/kg. The background concentrations of barium ranged from 27 to 390 mg/kg. There is no action level for barium. Onsite concentrations did not exceed background concentrations, so barium was not retained as a COC.

Beryllium was detected in one of four soil/sediment samples at 3.8 mg/kg. Beryllium was not detected in background samples (<3.0 - <36 mg/kg). There is no action level for this element. The average concentration of beryllium at Bullen Point is 2 mg/kg. Because beryllium was not detected below the sample quantitation limit in the background samples, surrogate geological information was evaluated. The average concentration of beryllium in the conterminous United States is 0.63 ± 2.38 mg/kg (USGS 1982). Assuming that two standard deviations from the mean derives the 95 percent confidence interval, the upper background concentration is 5.39 mg/kg. The Bullen Point installation is not within the region from which these background data were derived, but may provide a suitable range for comparison. The average concentration of beryllium at Bullen Point is within this background range, and the maximum detected concentration falls in this range as well. As a result, the last selection criteria for COCs is not met, and levels of beryllium are not considered elevated above background conditions. Beryllium was not retained as a COC.

Calcium was detected in all four soil/sediment samples. Concentrations ranged from 1,900 to 34,500 mg/kg. Background concentrations ranged from 360 to 59,000 mg/kg. There is no action level for calcium. Onsite concentrations did not exceed background concentrations, so calcium was not retained as a COC.

Chromium was detected in all four soil/sediment samples. Concentrations ranged from 2.7 to 18 mg/kg. The maximum background concentration was 47 mg/kg. The action level for chromium is 80 mg/kg. The detected concentrations did not exceed background concentrations, so this metal was not retained as a COC.

Copper was detected in all soil/sediment samples collected from the Bullen Point installation. Detected concentrations ranged from 3.4 to 13 mg/kg. Background concentrations ranged from <2.7 to 45 mg/kg. The action level for copper is 70 mg/kg. The detected concentrations did not exceed the background concentrations, so this metal was not retained as a COC.

Iron was detected in all four soil/sediment samples. Concentrations ranged from 4,300 to 15,000 mg/kg. The background concentrations ranged from 5,400 to 35,000 mg/kg. There is no action level for iron. Because the detected concentrations did not exceed background concentrations, this metal was not retained as a COC.

Lead was detected in one of four soil/sediment samples at a concentration of 40 mg/kg. The maximum background concentration for lead is 22 mg/kg. The average concentration is 12 mg/kg. The action level for lead is 35 mg/kg. Because the last selection criteria for COCs is not met (i.e., the average concentration of lead is less than the maximum background concentration and the maximum detected concentration is less than two times the maximum background concentration), levels of lead were not considered elevated above background conditions. As a result, lead was not retained as a COC.

Magnesium was detected in all four soil/sediment samples. Concentrations ranged from 1,100 to 3,000 mg/kg. The background concentrations for magnesium ranged from 360 to 7,400 mg/kg. There is no action level for magnesium. Because magnesium was not detected above background concentrations, it was not retained as a COC.

Manganese was detected in all four soil/sediment samples. Concentrations ranged from 45 to 76 mg/kg. The background concentrations for manganese ranged from 25 to 290 mg/kg. There are no action levels for manganese. Because onsite concentrations did not exceed background concentrations, this chemical was not retained as a COC.

Nickel was detected in all four soil/sediment samples ranging in concentration from 4.7 to 16 mg/kg. The background concentrations ranged from 4.2 to 46 mg/kg. The action level for nickel is 30 mg/kg. This metal was not retained as a COC because onsite concentrations did not exceed the background concentrations.

Potassium was detected in one of three soil/sediment samples at a level of 950 mg/kg. The background concentrations ranged from <300 to 2,200 mg/kg. There is no action level for potassium. This metal was not retained as a COC because onsite concentrations were below background concentrations.

Sodium was detected in three of four soil/sediment samples. Concentrations detected ranged from 52 to 690 mg/kg, which slightly exceeded the maximum background concentration of 680 mg/kg. There is no action level for sodium. The average concentration of sodium is 260 mg/kg. According to the COC selection criteria, twice the maximum background concentration is 1,360 mg/kg. The average sodium concentration did not exceed the maximum background concentration, and the maximum detected concentration was less than twice the maximum background concentration. Therefore, this metal was not retained as a COC.

Vanadium was detected in every soil/sediment sample ranging in concentration from 4.1 to 28 mg/kg. The background concentrations ranged from 6.3 to 59 mg/kg. There is no action level for vanadium. This metal was not retained as a COC because onsite concentrations were below background concentrations.

Zinc was detected in every soil/sediment sample at concentrations from 14 to 34 mg/kg. The background concentrations for zinc ranged from 9.2 to 95 mg/kg. The action level for zinc is 120 mg/kg. Because zinc was detected below background concentrations, it was not retained as a COC.

3.2 ECOLOGICAL EXPOSURE ASSESSMENT

The vegetation of the Arctic Coastal Plain and the ecosystems it characterizes have developed primarily as a result of the low relief and harsh environment. The growing season is short, typically extending from June through mid-September. Winters are long, cold, dry, and dark. Air temperatures that average below freezing for most of the year result in a permafrost layer that begins near the surface and reaches to depths as great as 610 meters. Seasonal thawing results in an active layer between ground surface and 3.7 meters below the surface (Hart Crowser 1987).

The impervious permafrost layer prevents percolation and infiltration of water below the active layer, and the generally flat terrain provides poor drainage. As a result, the ecosystems of the Arctic Coastal Plain are often defined not only by their plant associations but also by the degree of water found in and on them. Hart Crowser (1987) describes five major ecosystems for the classification of tundra and Arctic Coastal Plain communities:

- Marine zones: these include lagoons, estuaries, barrier islands, strands, and beaches. The abundance of vegetation along the marine coastal zone is inversely related to the amount of beach scouring by waves and ice. Mainland beaches support a variety of vegetation, including sedges, grasses, and forbs.

- Wet sedge meadows: an association of meadows, ponds, and lakes also known as "wet tundra". This system, with its associated wetlands, is dominant in the area extending west from the Colville River to the Chukchi Sea. Differences in vegetation within this ecosystem are related to moisture and microrelief.

- Tussock tundra: or "moist tundra" consisting primarily of areas dominated by tussock-forming cottongrass. This system covers significant portions of the Arctic Coastal Plain.

- Riverine systems and floodplains: including riparian shrubland on recent and old alluvium. Being better drained than surrounding lands, the riparian environment supports a distinctive "shrub thicket" vegetation.

- Alpine tundra: including rocky upland areas of sparse mat-forming or fell-field vegetation.

The species associated with each ecosystem at the Bullen Point DEW Line installation have the potential to be exposed to COCs if exposure pathways are complete. If pathways are complete, the representative species selected are considered potential receptors. Figure 3-1, Section 3.2.3, Potential Exposure Pathways, presents a schematic model of the potential exposure pathways.

The Ecological Exposure Assessment segment of the risk assessment contains: the most common species found at the DEW Line installations in Section 3.2.1; the representative species and the rationale used for their selection in Section 3.2.2; a discussion of the exposure pathways in Section 3.2.3; and a review of the habitat suitability for representative species in Section 3.2.4. Sections 3.2.5, 3.2.6, and 3.2.7 provide the methodology of the exposure assessment for representative plants, aquatic species, and birds and mammals, respectively. Life history tables, which provide species specific information for use in the exposure assessment, are included in Section 3.2.7.

3.2.1 Species of the Arctic Coastal Plain

The representative species used in the ERA for the Bullen Point installation were selected from species characteristic of the DEW Line installations along the Arctic Coastal Plain and are detailed in Sections 3.2.2.1 through 3.2.2.5.

The Bullen Point installation is located along the northern boundary of the Arctic Coastal Plain. Hart Crowser (1987) and Woodward-Clyde (1993) have listed the species likely to occur along the coastal plain based on site-specific studies and a review of the literature. The marine zone, wet sedge meadows, tussock tundra, and riverine/riparian are the primary ecosystems found at the Bullen Point installation. Alpine tundra is minimal at the site and is not evaluated further. Site-specific surveys of the ecosystems associated with the DEW Line installations have not been conducted for this risk assessment; however, a study investigating the abundance and distribution of Steller's and spectacled eiders was used (Alaska Biological Research 1994).

3.2.1.1 Plants. Plants commonly associated with the marine zone are sedges, grasses, and forbs. *Carex subspathacea* and *C. aquatilis* are dominant plants in the coastal wetlands.

The wet sedge meadow (also known as "wet tundra") is characterized by a variety of sedges and grasses. Typical species include: cottongrass, *Eriophorum* spp.; tundra grass, *Dupontia fischeri*; and mosses, *Sphagnum* spp.; Marsh marigold, *Caltha palustris*; and horsetail, *Equisetum* spp., which may be found in wetter areas (Hart Crowser 1987).

The tussock tundra (or moist tundra) is drier than the wet sedge meadow/wet tundra association. Tussock-forming cottongrass is the dominant plant species. Grasses, sedges, dwarf shrubs, mosses, and lichens are scattered throughout the tussock complex. These species include: willows, *Salix* spp.; Labrador tea, *Ledum palustri*; blueberry and lingonberry, *Vaccinium* spp.; and lousewort, *Pedicularis* spp. (NPRA Task Force 1978; Bergman et al. 1977).

Riverine/riparian systems are composed of a diversity of habitat types and species. The dominant plants are low-growing shrubs with a scattered understory of grasses and herbs. Larkspur, *Delphinium brachycentrum*; cinquefoil, *Potentilla* spp.; bearberry, *Arctostaphylos* spp.; and wormword, *Artemesia arctica* are common species (NPRA Task Force 1978; Bergman et al. 1977).

3.2.1.2 Aquatic Organisms. Sixty-six species of fish inhabiting marine, estuarine, and freshwater systems have been identified in the arctic region (Hart Crowser 1987). Marine species

inhabiting the nearshore and offshore waters include: boreal smelt, *Osmerus eperlanus*; Pacific herring, *Clupea harengus*; arctic cod, *Boreogagus saida*; and fourhorn sculpin, *Myoxocephalus quadricornis*. Anadromous species using arctic rivers for spawning include the arctic cisco, *Coregonus autumnalis*; arctic char, *Salvelinus alpinus*; and occasional pink and chum salmon, *Oncorhynchus* spp. Lack of overwintering habitat is a significant limiting condition for both anadromous and freshwater fish of the arctic region. The principal freshwater fish found in the region are grayling, *Thymallus arcticus*; lake trout, *Salvelinus namaycush*; burbot, *Lota lota*; and nine-spined stickleback, *Pungitius pungitius* (Hart Crowser 1987).

Invertebrates that may be present in the waters and wet habitats of the Arctic Coastal Plain are well represented by the crustaceans (i.e., copepods, isopods, amphipods, and decapods).

3.2.1.3 Birds. There are approximately 180 species of birds seasonally associated with the habitats of the Arctic Coastal Plain. Of these, many are shorebirds and waterfowl using migratory corridors that pass through the Bullen Point area. Bird use of the coastal plain is highly seasonal and associated with typical avian breeding and migration cycles. Shoreline habitats are used significantly in association with molting, pre-migratory staging, and post breeding movement. These habitats are considered critical by the U.S. Fish and Wildlife Service (USFWS 1982). Principal species include: glaucous gull, *Larus hyperboreus*; red phalarope, *Phalaropus fulicaria*; dunlin, *Calidris alpina*; loons, *Gavia* spp.; sandpipers, *Calidris* spp.; eiders, *Somateria* spp.; and geese, *Branta* spp. and *Chen* sp. Among the migratory passerine species using the coastal habitats are the Savannah sparrow, *Passerculus sandwichensis*; common and hoary redpolls, *Carduelis* spp.; snow bunting, *Plectrophenax nivalis*; and Lapland longspur, *Calcarius lapponicus* (Woodward-Clyde 1993).

3.2.1.4 Mammals. The mammalian fauna of the Arctic Coastal Plain and adjacent waters is relatively simple compared to fauna at lower latitudes. A review of species lists indicates a total of 38 species that commonly occur in the arctic; 11 of these are marine mammals (Hart Crowser 1987). A sampling of the terrestrial mammals geographically associated with the DEW Line stations, including Bullen Point, consists of brown lemming, *Lemmus trimucronatus*; masked shrew, *Sorex cinerus*; arctic fox, *Alopex lagopus*; red fox, *Vulpes vulpes*; weasels, *Mustela* spp.; tundra vole, *Microtus oeconomus*; caribou, *Rangifer tarandus*; and grizzly bear, *Ursus arctos* (Hart Crowser 1987; Woodward-Clyde 1993).

Marine mammals of the arctic coast include polar bear, *Ursus maritimus*; walrus, *Odobenus rosmarus;* six species of whales; and five species of seals. The most common of the whale and seal species are beluga, *Delphinapterus leucas*; bowhead whale, *Balaena mysticetus*; gray whale, *Eschrichtius robustus*; ringed seal, *Phoca hispida*; and bearded seal, *Erignathus barbatus* (Hensel et al. 1984).

3.2.1.5 Threatened and Endangered Species. Species of the Arctic Coastal Plain and nearby waters that are protected by federal and state designations include bowhead whale (endangered); fin whale, *Balaenoptera physalus* (endangered); sei whale, *Balaenoptera borealis* (endangered); and humpback whale, *Megaptera novaengliae* (endangered). The gray whale was delisted by the National Marine Fisheries Service as of 16 June 1994. Avian species include the spectacled eider, *Somateria fischeri* (threatened), and Steller's eider, *Polysticta stelleri* (candidate

for listing). Based on the latest federal and state lists (June 1995) of threatened and endangered plant species, no plant species at the DEW Line installations are currently listed.

3.2.2 Representative Species

It is impractical to evaluate all of the potential receptors individually because of the great diversity of plants and animals at a given site. Thus, for ERAs, a set of "representative species" is selected for further evaluation. The representative species are selected primarily on the species' likelihood of exposure based on their preferred habitat and feeding habits, and the distribution of contaminants. Potential exposure pathways are shown in Figure 3-1 and discussed in Section 3.2.3. The abundance of a species, relative to the areal extent of the sites, is also considered. The representative species encompass a range of ecological niches in order to achieve the best characterization of the ecosystems being examined. In addition, species are selected, in part, as a result of the availability of toxicity, exposure, and life history information. Species that may be sensitive to environmental impacts, such as endangered or threatened species, are also evaluated. Any endangered or threatened species discussed in the ERA are not considered representative of the Arctic Coastal Plain or the Air Force arctic radar installations. These species are evaluated to provide information about whether they face potential risks from exposure to the COCs being evaluated in the ERA.

For the DEW Line stations, groups of receptors are evaluated, including plants, aquatic invertebrates, fish, birds, and mammals. Potential risks to representative species are estimated by evaluating sampling data for the relevant exposure media (i.e., soil, sediments, and surface water). For plants, soil/sediment COC data are used to estimate potential uptake. For aquatic species, surface water COC concentrations are used to estimate exposure; and for the birds and mammals selected, exposures are estimated by evaluating their potential dietary intakes of COCs. No site-specific studies were conducted to determine exposure or toxicity levels at the installation.

The similarity of ecosystems at each of the installations allows the use of the same set of representative species for all installations. It may be possible that a representative species inhabits the general area of an installation, but does not occur specifically on the installation property. When and if this situation occurs, it will be noted. The receptors that are selected specifically as representative species for the Bullen Point installation are listed in the paragraphs that discuss the representative groups (i.e., plants, aquatic organisms, birds, mammals, and threatened or endangered species). Table 3-4 presents the representative and sensitive species for arctic coastal DEW Line installations, including endangered and threatened species that may be potentially exposed. The USFWS was consulted about the occurrence and selection of threatened and endangered species.

3.2.2.1 Representative Plants. Plants selected as representative species are: sedges, willows; cottongrass; and various berry-bearing shrubs, *Vaccinium* spp. These species are selected because they are abundant on all the sites, are important links in the trophic structure of the ecosystems of the arctic, and represent a major percentage of the primary production along the coastal plain. The blueberry, huckleberry, and lingonberry, *Vaccinium* spp., are

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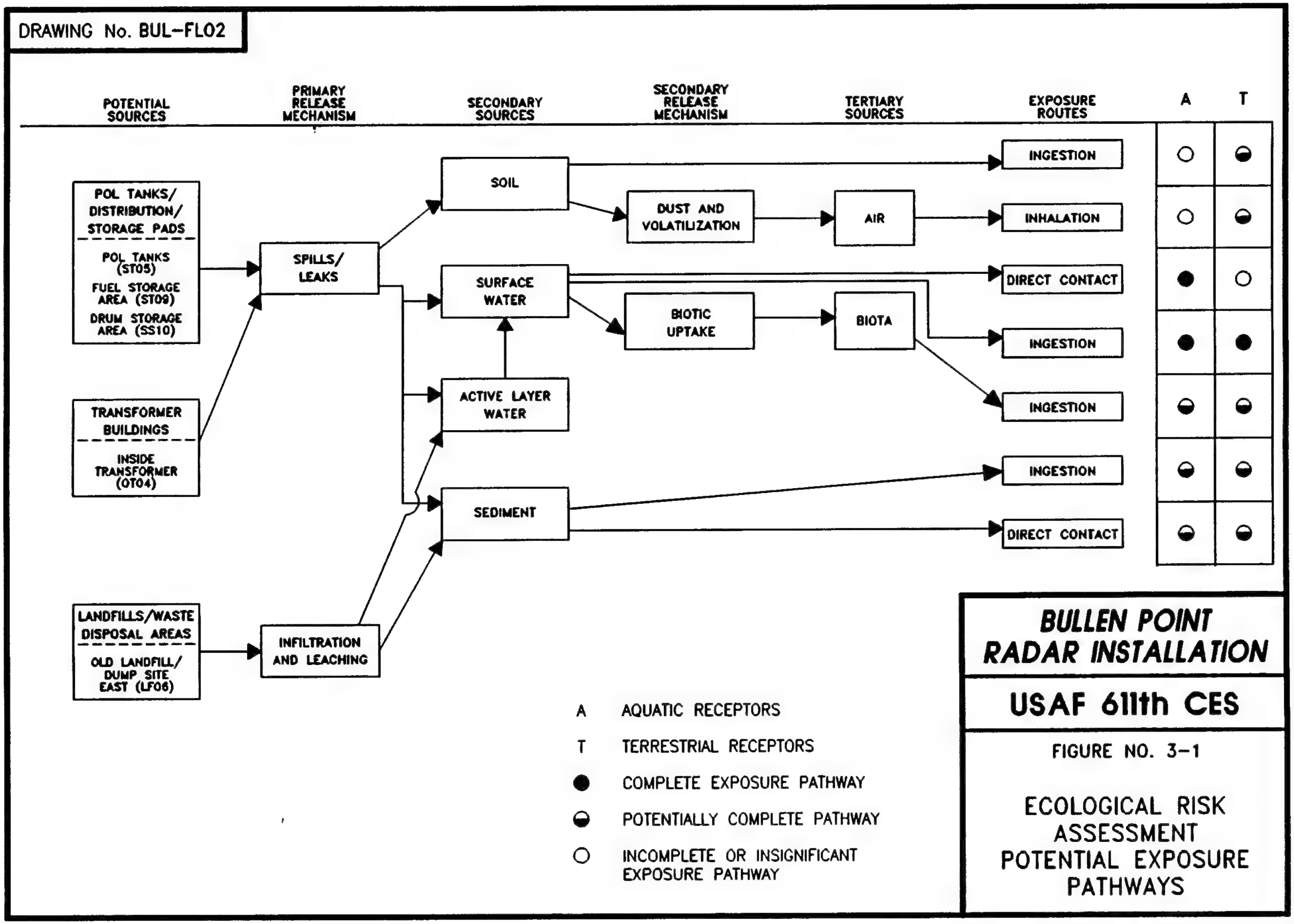
DRAWING No. BUL-FL02
POTENTIAL SOURCES
PRIMARY RELEASE MECHANISM
SECONDARY SOURCES
SECONDARY RELEASE MECHANISM
TERTIARY SOURCES
EXPOSURE ROUTES
A
T
POL TANKS/ DISTRIBUTION/ STORAGE PADS
POL TANKS (ST05)
FUEL STORAGE AREA (ST09)
DRUM STORAGE AREA (SS10)
TRANSFORMER BUILDINGS
INSIDE TRANSFORMER (OT04)
LANDFILLS/WASTE DISPOSAL AREAS
OLD LANDFILL/ DUMP SITE EAST (LF06)
SPILLS/ LEAKS
INFILTRATION AND LEACHING
SOIL
SURFACE WATER
ACTIVE LAYER WATER
SEDIMENT
DUST AND VOLATILIZATION
BIOTIC UPTAKE
AIR
BIOTA
INGESTION
INHALATION
DIRECT CONTACT
INGESTION
INGESTION
INGESTION
DIRECT CONTACT
A AQUATIC RECEPTORS
T TERRESTRIAL RECEPTORS
COMPLETE EXPOSURE PATHWAY
POTENTIALLY COMPLETE PATHWAY
INCOMPLETE OR INSIGNIFICANT EXPOSURE PATHWAY
BULLEN POINT RADAR INSTALLATION
USAF 611th CES
FIGURE NO. 3-1
ECOLOGICAL RISK ASSESSMENT POTENTIAL EXPOSURE PATHWAYS

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TABLE 3-4. REPRESENTATIVE AND SENSITIVE SPECIES AT THE ARCTIC DEW LINE INSTALLATION SITES

COMMON NAME	GENUS AND SPECIES
PLANTS	
Sedge	*Carex* spp.
Cottongrass	*Eriophorum* spp.
Willow	*Salix* spp.
Berries	*Vaccinium* spp.
AQUATIC ORGANISMS	
Water fleas	*Daphnia* spp.
Nine-spined stickleback	*Pungitius pungitius*
Arctic char	*Salvelinus alpinus*
BIRDS	
Lapland longspur	*Calcarius lapponicus*
Brant	*Branta bernicla*
Glaucous gull	*Larus hyperboreus*
Pectoral sandpiper	*Calidris melanotos*
MAMMALS	
Brown lemming	*Lemmus trimucronatus*
Arctic fox	*Alopex lagopus*
Barren-ground caribou	*Rangifer tarandus*
ENDANGERED AND THREATENED SPECIES*	
Spectacled eider[a]	*Somateria fischeri*
Steller's eider[b]	*Polysticta stelleri*

* See Section 3.2.2.5 for information about endangered and threatened species.
a Threatened status.
b Candidate for threatened status, see text for explanation.

evaluated because of their roles as forage plants and as subsistence species. All of these representative species are evaluated at the Bullen Point installation.

3.2.2.2 Representative Aquatic Invertebrates and Fish. The invertebrates selected as representative species are *Daphnia* spp. (water fleas). The fish species chosen are the arctic char and the nine-spined stickleback. *Daphnia* spp. are abundant and represent a portion of the diet of the selected fish species (Johnson and Burns 1984; Wootton 1976), and toxicity information is readily available for them. The arctic char is a common anadromous species (exposed to both fresh and saltwater) and is a valuable recreation and subsistence resource (Johnson and Burns 1984). The nine-spined stickleback is a freshwater species that also uses brackish habitats, nests in aquatic vegetation, and is prey for other fish and bird species (Wootton 1976). The nine-spined stickleback, arctic char, and *Daphnia* spp. will be evaluated in this ERA. No marine mammals are evaluated in the Bullen Point ERA because there are no complete pathways for COC's (at concentrations that are of concern) to reach potential marine receptors.

3.2.2.3 Representative Birds. The representative avian species are Lapland longspur; brant, *Branta bernicla*; glaucous gull; and pectoral sandpiper, *Calidris melanotos*. The Lapland longspur is a passerine belonging to a terrestrial feeding guild (including sandpipers, turnstones, and phalaropes) (Custer and Pitelka 1978). The longspur's diet of insects and seeds (Custer and Pitelka 1978) makes it an important link in the arctic trophic web. The brant nests and molts among the numerous ponds in the tussock tundra and grazes on sedges and cottongrass (Palmer 1976). It is considered to be an important subsistence resource. The glaucous gull is a predatory scavenger that feeds on small mammals, young birds, carrion, and garbage, and breeds along the Arctic Coastal Plain (Farrand 1983). The pectoral sandpiper is an abundant shorebird that is primarily insectivorous and breeds on the Arctic Coastal Plain. The Lapland longspur, brant, glaucous gull, and pectoral sandpiper are in potential exposure pathways at the Bullen Point installation and will be evaluated in this ERA. All the avian species in this ERA are migratory, and as such, are protected under the Migratory Bird Treaty of 1978. This is reflected by the use of a protected species factor of 2 in the calculation of avian toxicity reference values.

3.2.2.4 Representative Mammals. The representative species of mammals selected are the brown lemming, arctic fox, and the barren-ground caribou. The brown lemming is the predominant small mammal at all installations. The lemming consumes more vegetation than expected for an animal its size, due to its low assimilation efficiency, the low nutrient value of winter forage, and the high metabolic demands of the arctic environment (Chappell 1980). The arctic fox is selected as a representative species because it is ubiquitous along the coastal plain and its carnivorous diet (mostly lemmings) places it near the top of the trophic structure in the arctic. Eberhardt et al. (1982) note that in fall and winter, and to a lesser extent in summer, the arctic fox frequently uses areas near development. This tendency may expose the fox to potential pathways of contamination. Additionally, the fox, a relatively common furbearer, can be an important subsistence resource. The caribou is selected as a representative species because it uses areas on, or near, a number of the radar installations during migration, calving, and post-calving. In addition, the caribou is a significant subsistence resource for local people along the Arctic Coastal Plain (USFWS 1982; Cuccarese et al. 1984; Hensel et al. 1984). The

three mammal species discussed may be potentially exposed to COCs at the Bullen Point installation and will be evaluated in this ERA.

3.2.2.5 Threatened and Endangered Species. The threatened and endangered species that potentially occur at the DEW Line installations are the spectacled eider and Steller's eider. The spectacled eider is federally listed as threatened, and Steller's eider is a candidate for listing as threatened. The U.S. Fish and Wildlife Service indicated that it was likely that Steller's eider would be listed as threatened sometime in 1995 (Ambrose 1994 pers. comm.), but a federal moratorium on additions to the threatened and endangered lists is in effect. Alaska Biological Research (1994) conducted surveys searching for spectacled and Steller's eiders on and near the DEW Line installations. The surveys report that spectacled eiders were observed near the Bullen Point installation, but there is little chance that Steller's eiders will use the habitats near Bullen Point. As a result, spectacled eiders, but not Steller's eiders, will be evaluated in this ERA. Because of the ecological similarity of spectacled and Steller's eiders (i.e., relatively similar morphology, physiology, niche, and trophic status), this evaluation will serve as a surrogate indicator of risk to Steller's eiders in the event that the species has a complete exposure pathway to a COC at Bullen Point. The arctic subspecies of peregrine falcon, *Falco peregrinus tundrius*, was delisted by the USFWS as of 5 October 1994.

3.2.3 Exposure Pathways

This section discusses potential exposure pathways for ecological receptors. In addition, methods used to quantify exposures to selected species of plants, aquatic organisms, birds, and mammals are presented. Quantitative estimates of exposure will be compared with toxicity reference values (TRVs) derived in Section 3.3 in order to estimate risks in the risk characterization section (Section 3.4).

Ecological receptors can be exposed to COCs through abiotic and biotic media. Potential exposure pathways for terrestrial and aquatic organisms are summarized in Figure 3-1. The following sections describe the potential exposure routes and a determination of pathways evaluated in the risk assessment.

Potential risks to representative species of plants from exposure to COCs in soil and water will be addressed. The most significant route of exposure for plants is direct contact with soil at the site, although a qualitative evaluation of the effects of COCs in surface water is presented in Section 3.4.1.

Aquatic organisms such as fish and invertebrates are primarily exposed through direct contact with surface water. Surface water is in direct contact with dermal surfaces as well as gills and other respiratory structures. Fish and invertebrates also may be exposed to COCs through ingestion of plant and animal items in the diet, direct contact with sediments, and incidental ingestion of sediments while foraging. Direct contact with surface water is the primary exposure route; therefore, these secondary routes will not be evaluated for aquatic organisms.

Wildlife, such as birds and mammals, may be exposed to COCs through a variety of pathways including ingestion of surface water used for drinking, ingestion of plant and animal diet items,

and incidental ingestion of surface soils and sediments while foraging. Wildlife species are not expected to be exposed to COCs via inhalation because the surface soils are well vegetated and moist during the growing season and frozen and/or snow covered the remainder of the year. Therefore, the inhalation pathway is not evaluated in the ERA.

Insufficient toxicity and exposure information is available for the representative species to allow quantification of exposures from dermal contact with soil or sediments; therefore, these pathways were not quantitatively evaluated. Because soils and sediments represent potential pathways, total exposures for the representative species could be underestimated. This represents one of the uncertainties in this risk assessment that are discussed in Section 3.5.

The soil and sediment samples at the Bullen Point installation are taken at depths ranging from the surface to four feet deep. Only those samples at or above 1.5 feet deep were used in the ecological risk assessment because the potential exposure pathways for the representative species are likely to be incomplete at depths greater than 1.5 feet. It is unlikely that any of the representative species would be exposed to any soil or sediments much below one foot, although the brown lemming is reported to burrow up to one foot deep (Nowak 1991). As a result, samples below 1.5 feet cannot be considered ecologically relevant for the representative species being evaluated. This depth-oriented sample screening contributes to a conservative risk assessment (a potential overestimation of risk).

3.2.4 Habitat Suitability for Representative Species

In order to assess the representative species' degree of exposure to the COCs, the habitat suitability of each of the five sites was evaluated. The habitat suitability evaluation considered the representative aquatic, avian, and mammalian species selected for evaluation at the Bullen Point installation.

Human development and activities at the Bullen Point installation have impacted the natural habitats available to the representative species. The effects of these impacts are uncertain; in some cases the activities probably deter wildlife use of the area and in other cases they may attract wildlife (e.g., arctic fox and gulls attracted to a landfill). Because the Bullen Point installation was deactivated in 1971 and is presently operated as an unmanned facility, the activity-related impacts are currently minimal, and ecological receptors, including the representative species, may use any or all of the sites at the Bullen Point installation. Therefore, all the sites at the Bullen Point installation are evaluated in this ERA. In some cases, the media-specific samples have been taken at locations that do not represent suitable habitat for all the representative species (e.g., under-building sample locations that are obviously not suitable for caribou, or surface water sample locations that are not accessible to fish species). This may result in an overestimate of exposure because sample data from all locations are used to calculate the average concentrations which, in turn, are used to estimate exposure for the representative species. These conditions will be noted in the risk characterization and uncertainty sections to be presented in the ERA (Sections 3.4 and 3.5, respectively).

The ERA is being conducted for the entire Bullen Point installation, but only a portion of the facility consists of potentially contaminated sites. The sites are estimated to total approximately

0.5 hectare (ha), or 1.3 acres. The areal extent of the potentially contaminated sites has been estimated using site maps. The spatial extent of the sites is considered when estimating the onsite dietary intake (IS) in Section 3.2.7.2. In general, based on professional judgement and onsite observations but not on site-specific surveys, the installation provides habitat less suitable than nearby areas because of the numerous roads, gravel pads, and overall development.

3.2.5 Exposure Assessment for Representative Species of Plants

The harsh environment of the Arctic Coastal Plain imposes many restrictions on plant life. The presence of permafrost limits infiltration and percolation of water, so the water table is often at or above the surface. Most plant species are perennial, with much of their biomass (50 to 98 percent) underground (Raven et al. 1986). The potential pathways of contamination for plants are through the soil/sediment and surface water.

Carex spp., *Salix* spp., and *Eriophorum* spp. all store food reserves in rhizomes. Mychorrhizal fungi play an important role in the transport and delivery of nutrients to the rhizomes and the roots of these species. This underground system probably developed in response to the harsh aboveground arctic environment. As a result, surface water contaminated with chemicals that are lighter than water (i.e., petroleum and its derivatives) does not present a greatly increased hazard to the below-ground portion of plants. This has been shown experimentally by exposing arctic coast vegetation to petroleum products (Walker et al. 1978). The experiments showed that sedges, willows, and cottongrass plants were not adversely affected by low to moderate amounts of petroleum (spill concentrations in the studies were up to 12 L/m^2) in wet environments. Thus, soil/sediment will be considered the primary pathway of potential contamination for plants. The chemical concentration used in the risk characterization (Section 3.4) is the average concentration of the COC in the soil/sediments at the installation. A qualitative evaluation of the effect of potentially contaminated surface water on plants is presented in Section 3.4.1.

3.2.6 Exposure Assessment for Representative Aquatic Organisms

Organisms that dwell in an aquatic environment are exposed to chemicals contained in the water column. For this reason, the exposure assessment considers the concentrations in surface water to be the exposure concentrations to aquatic organisms. As described in Section 3.2.3, the primary exposure route for aquatic organisms is direct contact with surface water, and as a result, the aquatic representative species are not evaluated for contact with, or ingestion of, sediments. The risk assessment compares the average concentration of the COCs found in surface waters to toxicity data for the representative aquatic species to calculate the risk estimate.

3.2.7 Exposure Estimates for Representative Bird and Mammal Species

Exposure estimates for the representative species of mammals and birds (expressed as a unit of chemical ingested per unit of body weight) are based on their total exposure to COCs from diet, soils, and surface water using the following equation:

$$EE = [(FI \times CF) + (WI \times CW) + (SI \times CS \times ROA)] \times UCF \times IS / BW$$

where:

EE	=	estimated exposure (mg/kg-bw/day).
FI	=	food intake rate (g/day); rates are derived in the life history tables (Tables 3-5 through 3-13). Diets (both vegetable and animal components) are proportioned according to the diet composition information in the life history tables and are presented below.
CF	=	chemical concentration in food (mg/kg); based on concentrations for each group of food items.
WI	=	water intake rate (L/day); rates are derived in the life history tables.
CW	=	chemical concentration in water (μg/L); see Section 3.1 for calculations of concentrations.
SI	=	soil/sediment intake rate (g/day); based on a percentage of food intake.
CS	=	chemical concentration in soil/sediment (mg/kg); see Section 3.1 for calculations of concentrations.
ROA	=	relative oral availability; default to 1.0 (lack of information). This value assumes that the bioavailability of the chemical in the test medium is the same as for the medium onsite.
UCF	=	0.001; unit conversion factor used in conversion of g to kg, μg to mg., and L to ml, to ensure EE is reported in mg/kg-bw/day.
IS	=	fraction of dietary intake at potentially contaminated sites (by weight).
BW	=	body weight (kg)

In the case of species that have partial herbivorous dietary intakes, the CF x FI phrase in the equation is multiplied by the proportion of vegetation in their diet (these calculations are presented in Appendix C, Bioconcentration Factor Calculations, and Appendix D, Concentration in Food Calculations). Those species and their respective proportions are: Lapland longspur, 0.25; brant, 0.90; glaucous gull, 0.10; pectoral sandpiper, 0.10; and spectacled eider, 0.25 (see the life history tables for references regarding the proportion of vegetation in the species' diets). The estimated exposure calculations for bird and mammal receptors are presented in Appendix E.

3.2.7.1 Potential Bioaccumulation of COCs in Representative Species. The potential risks from ingestion of COCs in dietary items are difficult to determine because of the complexity of the trophic web. Inputs to the exposure estimate equation include concentrations of contaminants in water and soil, ingestion rates for water, food, and soil, the relative use of the contaminated sites compared to the representative species' normal range, and body weight. The food ingested, in the case of higher level consumers, may be from different levels of the trophic web. For example, a contaminant may be taken up by a plant, which is consumed by a lemming, which is then eaten by an arctic fox. The amount of contaminant to which the fox is exposed is not readily quantified without supporting empirical data at each trophic level. Because of this and the lack of data to assist in quantifying bioaccumulation, the risk assessment does not account for bioaccumulation in the animal portion of the trophic web. This uncertainty is tempered by the "hot spot" nature of the distribution of the COCs. It is possible that representative species may be exposed to these "hot spots" occasionally, but it is unlikely that their entire exposure will occur at these locations. Use of the average concentrations may overestimate the potential exposure

of representative species (this is discussed in more detail in the ERA Uncertainty Analysis, Section 3.5.1). Furthermore, the likelihood of predators repeatedly taking prey that have been exposed to a COC "hot spot" is low. For example, the arctic fox ranges over such a wide area that any COCs the fox would be exposed via bioaccumulation would represent only a very small proportion of its overall exposure.

Further, most of the COCs in soils/sediments at the Bullen Point installation are volatile organic compounds that are unlikely to bioaccumulate. For illustrative purposes, bioconcentration factors (BCFs) calculated for the organic COCs are presented in Table 3-5 (Veith et al. 1979 in Spacie and Hamelink 1985). Based on these low BCFs, the exposure estimates for organic chemicals do not include potential bioaccumulation of COCs in the animal portion of the trophic web. It is unlikely that the organic chemicals will bioaccumulate (based on the concentrations reported in the soil and water) such that the exposure estimates would exceed, or even approach, the TRVs. Bioconcentration factor calculations are presented in Appendix C.

The only inorganic COC at Bullen Point, iron, is found in surface water. Surface water concentrations are not used to quantify potential plant uptake, but the iron concentration at Bullen Point is only slightly outside the range of background concentrations (detection of 2,900 µg/L versus a maximum background concentration of 2,800 µg/L). This concentration of iron is sufficiently low to alleviate concern about bioaccumulation of iron in plants via a surface water route. The bioaccumulation of metals in the animal portion of the trophic web is not amenable to quantification without sample concentrations at each level of consumer. Information about the bioaccumulation of iron is not available in the literature, but iron is an essential nutrient. Therefore, it is likely that metabolic processes that make use of iron will prevent undue bioaccumulation.

TABLE 3-5. BIOCONCENTRATION FACTORS FOR SELECTED ORGANIC COMPOUNDS IN WATER

CHEMICAL	Log K_{ow}	BCF
DRPH	5.30	6,238
Naphthalene	3.36	211
Trimethylbenzene	3.78	439
Xylene	3.16	149

Note: BCF calculated from Log K_{ow} according to the following equation:
Log BCF = 0.76 Log K_{ow} - 0.23 (Veith et al. 1979 in Spacie and Hamelink 1985)
K_{ow} = octanol/water partition coefficient

3.2.7.2 Estimation of Percent Ingested Onsite. The size of the areas used by the representative species, and hence their potential exposure to COCs, varies greatly. Generally, a species' home range is used to characterize the size of the area it uses on a regular basis (disregarding migration and dispersal). This information, combined with the extent of the potentially contaminated sites, can be used to estimate the percent of dietary intake that a species gets from the sites.

This estimate is referred to as the "percent of dietary intake at sites" (IS) value in the exposure estimate equation. The IS value is represented by the ratio of the total area of the sites (0.5 ha or 1.3 acres) to the reported home range size (or converted population density values) for the representative species. When home range information for a species was not available, population density values were used to estimate the area used by the species. The representative species are most likely to be at Bullen Point during, or directly after, the breeding season, when many species become territorial. These territories represent the area used by the species. The densities of the population may provide estimates of the size of the territories and are used as substitute values when home range information is unavailable. This presents an added degree of uncertainty (see Section 3.5.3). If the home range (or converted population density value) is less than the total areal extent of the sites (0.5 ha), the maximum value for IS is 1.0 because it is possible that a species could meet all its dietary intake needs within the potentially contaminated areas. The IS values for the representative bird and mammal species are given below. Note that this is a conservative estimate because the 0.5 ha size assumes that the contaminated sites are the only area used. Obviously, the species would use the suitable areas between the potentially contaminated sites, and this results in less potential exposure to COCs than if the species restricted its location to contaminated sites only.

Birds. Lapland longspur. IS = 0.2; Derksen et al. (1981) report a breeding density of 38.6 birds/km^2. This corresponds to about 1 bird/2.6 ha, and results in an IS value of 0.2.

Brant. IS = 0.03; density of breeding pairs reported by Derksen et al. (1981) is 5.0 birds/km^2. At this density of 1 brant/20 ha, the total extent of the potentially contaminated sites is about 3 percent of the area a brant might use.

Glaucous gull. IS = 0.01; the density for the glaucous gull is reported by Derksen et al. (1981) as 0.8 birds/km^2. This density, about 1 gull/125 ha, yields an IS value of less than 0.01, but 0.01 is used as a minimum IS value.

Pectoral sandpiper. IS = 0.1; the density of the pectoral sandpiper along the Arctic Coastal Plain is reported by Derksen et al. (1981) as 22.4 birds/km^2. This density equates to one sandpiper/4.5 ha, and a corresponding IS value of approximately 0.1.

Spectacled eider. IS = 0.01; Derksen et al. (1981) report an average population density of 0.32 birds/km^2 for the spectacled eider. The resulting density of 1 bird/312.5 ha in 1981 may currently be too high considering the decline in the species' population. This results in selecting the minimum IS value of 0.01, but an overestimation of exposure may be considered appropriate in the evaluation of a sensitive species.

Mammals. Brown lemming. IS = 0.5; the lemming's home range is reported as 0.5 ha (Nowak 1991). It is possible that several lemmings may consume all their dietary needs within the bounds of a site. However, the lemming is not likely to use the wetter sites (which constitute well over 50 percent of the total extent of the sites), where the majority of the contaminant pathways are located. The sites are mostly gravel pads that have been constructed for development purposes, support little or no vegetation, and offer a poor matrix for the lemming to use for burrowing. For these reasons the IS used for the brown lemming is 0.5 rather than 1.0.

Arctic fox. IS = 0.01; the home range of the fox is extremely variable. Eberhardt et al. (1982) report a home range of 3.7 to 20.8 km^2 for juvenile and adult arctic foxes, respectively. Even the lower end of this range (3.7 km^2 or 370 ha) is over 700 times greater than the extent of the potentially contaminated sites, hence the minimum IS value of 0.01 is used.

Caribou. IS = 0.01; caribou are highly mobile, covering large distances during their movements to and from calving grounds and in their constant search for suitable forage. They may range over thousands of km/year, and as a result there is no accurate estimate of their home range. Based on knowledge of the caribou's habits and professional judgement, a very conservative estimate of the likelihood of caribou using the potentially contaminated sites is one percent, or the corresponding minimum IS value of 0.01.

3.2.7.3 Exposure Assessment for Representative Species of Birds. In this section the methods for quantifying exposures to the selected representative species of birds are presented.

In order to estimate exposures of the representative species of birds, life history information was compiled for the selected species. This information includes: occurrence at the DEW Line sites, habitat, average body weight, estimated food intake rate, estimated water intake rate, diet composition, and home range and/or population density.

Plant uptake of contaminants has been quantified for use in the exposure estimations for herbivores (bird and mammal species). Herbivores are potentially exposed to contamination directly from ingestion of soil and water intake as well as through their diet. The dietary plant component (CF in the exposure estimate equation) is calculated by multiplying the contaminant's soil concentration by the BCF, B_v. B_v is defined as the ratio of the concentration in aboveground parts of a plant (mg of compound/kg of dry plant) to the concentration in soil (mg of compound/kg of dry soil). The B_v can be used to predict the level of a potential contaminant taken up by a plant, and this information can then be used to assess the potential transport of the contaminant in the trophic web.

The uptake of metals by plants is quantified using the B_v values in Baes et al. (1984). These values represent potential uptake to the vegetative portions of the plant. The approach for organic chemicals is basically the same, except that the B_vs for organic chemicals are derived using a regression equation (Travis and Arms 1988). The equation is:

$$\log B_v = 1.588 - 0.578(\log K_{ow})$$

where:

B_v = the BCF (unitless) and

K_{ow} = the octanol-water partition coefficient of the chemical (mol/m^3 / mol/m^3)

In order to calculate the potential uptake of DRPH by plants, the K_{ow} of diesel fuel was estimated. The estimation of the K_{ow} was conducted using equation 2-3 in Lyman et al. (1982):

$$\log S = -0.922 \log K_{ow} + 4.184$$

where:

S = solubility (mg/L) and

K_{ow} = octanol/water partition coefficient (mol/m^3 / mol/m^3)

This equation estimates the solubility of an organic chemical in water. However, it may also be manipulated arithmetically to calculate the log K_{ow} based on the known solubility:

$$\log K_{ow} = \frac{\log S - 4.184}{-0.922}$$

The solubility of diesel fuel (0.2 mg/L) (Custance et al. 1992) was used to calculate the log K_{ow} of diesel fuel. The log K_{ow} is calculated to be 5.3.

Life history information for the Lapland longspur, brant, glaucous gull, pectoral sandpiper, and spectacled eider (although the spectacled eider is a threatened species, it is presented with the other avian species) is presented in Tables 3-6 through 3-10.

Information is not available on the daily food intake rate (grams/day) and water intake rate (liters/day) for the representative bird species in the arctic habitat. Therefore, this information was estimated using regression equations associated with body weight (Calder and Braun 1983). The severity of the arctic climate may impose higher metabolic demands on animals. As a result, the food and water intake rates should be considered estimates only, and their uncertainty should be kept in mind. The food intake rate was estimated using Nagy's (1987) equations:

Passerine birds (i.e., Lapland longspur):

$$\text{FI (kg/day dry matter)} = 0.141 \times (\text{body weight in kilograms})^{0.850}$$

All other birds:

$$\text{FI (kg/day dry matter)} = 0.0582 \times (\text{body weight in kilograms})^{0.651}$$

The water intake rate was estimated using the equation developed by Calder and Braun (1983):

All birds:

$$\text{WI (liters/day)} = 0.059 \times (\text{body weight in kilograms})^{0.67}$$

TABLE 3-6. LIFE HISTORY INFORMATION FOR THE LAPLAND LONGSPUR, *Calcarius lapponicus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	seasonal breeder at all arctic coastal radar stations	dominant breeding passerine	USAF 1993
Habitat	breeds on arctic coastal tundra		Scott 1983
Body Weight	27.3 g (0.027 kg)	mean of 68 specimens	Dunning 1984
Food Intake Rate	6.5 g/day dry matter	$FI=0.141(BWkg)^{0.850}$	Nagy 1987
Water Intake Rate	0.005 liters/day	$WI=0.059(BWkg)^{0.67}$	Calder and Braun 1983
Diet Composition	during breeding (June and July): insects (craneflies); pre- and post-breeding (May and August): seeds (grasses); average 25% vegetation in diet	passerine member of insectivorous foraging guild which includes shorebirds	Custer and Pitelka 1978
Population Density	$38.6/km^2$	varies with changing predation pressures	Derksen et al. 1981

TABLE 3-7. LIFE HISTORY INFORMATION FOR THE BRANT, *Branta bernicla*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	seasonal breeder at or near all arctic coastal radar stations	breeding, migratory sp., subsistence sp.	USAF 1993
Habitat	breeds on Arctic Coastal Plain	prefers low, barren, wet, coastal terrain	Palmer 1976
Body Weight	1,305 g (1.305 kg)	mean of 791 specimens	Dunning 1984
Food Intake Rate	69.2 g/day dry matter	$FI=0.0582(BWkg)^{0.651}$	Nagy 1987
Water Intake Rate	0.07 liters/day	$WI=0.059(BWkg)^{0.67}$	Calder and Braun 1983
Diet Composition	sedges, grasses; average 90% vegetation in diet	some insects during breeding (June and July)	Palmer 1976
Population Density	$5.0/km^2$	average from 3 coastal sites	Derksen et al. 1981

TABLE 3-8. LIFE HISTORY INFORMATION FOR THE GLAUCOUS GULL, *Larus hyperboreus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	seasonal breeder and migrant at or near all arctic coastal radar stations	relatively common along arctic coast	Woodward-Clyde 1993
Habitat	coastal tundra, lakes, ponds, and marine environment	breeds on arctic coast	Farrand 1983
Body Weight	1,445 g (1.445 kg)	mean of 65 specimens	Dunning 1984
Food Intake Rate	74 g/day dry matter	$FI=0.0582(BWkg)^{0.651}$	Nagy 1987
Water Intake Rate	0.08 liters/day	$WI=0.059(BWkg)^{0.67}$	Calder and Braun 1983
Diet Composition	small fish, birds, insects, crustaceans, mollusks, garbage; average 10% of vegetation in diet	predatory scavenger	Martin et al. 1961
Population Density	$0.8/km^2$	average from 3 coastal sites	Derksen et al. 1981

TABLE 3-9. LIFE HISTORY INFORMATION FOR THE PECTORAL SANDPIPER, *Calidris melanotos*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	seasonal breeder at all arctic coastal radar stations	abundant on Arctic Coastal Plain	Woodward-Clyde 1993
Habitat	grassy margins of wet meadows, marshes, riparian areas, ponds	nests hidden on well-drained grassy sites	Scott 1983; Martin et al. 1961
Body Weight	79 g (0.079 kg)	mean of 35 specimens	Dunning 1984
Food Intake Rate	11.2 g/day dry matter	$FI=0.0582(BWkg)^{0.651}$	Nagy 1987
Water Intake Rate	0.01 liter/day	$WI=0.059(BWkg)^{0.67}$	Calder and Braun 1983
Diet Composition	insects, mollusks, crustaceans, worms, vegetable debris; average 10% vegetation in diet	craneflies are major diet component	Martin et al. 1961; Pitelka 1959
Population Density	$22.4/km^2$	average from three coastal sites	Derksen et al. 1981

TABLE 3-10. LIFE HISTORY INFORMATION FOR THE SPECTACLED EIDER, *Somateria fischeri*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	potential seasonal breeder at all arctic coastal radar stations	winter whereabouts unknown	Woodward-Clyde 1993
Habitat	marine when not breeding, nests on coastal tundra	nests on islets in tundra ponds and lakes, as well as ashore	Palmer 1976
Body Weight	1,375 g (1.375 kg)	mean of 32 specimens	Dunning 1984
Food Intake Rate	71.6 g/day dry matter	$FI=0.0582(BWkg)^{0.651}$	Nagy 1987
Water Intake Rate	0.07 liters/day	$WI=0.059(BWkg)^{0.67}$	Calder and Braun 1983
Diet Composition	75% insects, mollusks, crustaceans; average of 25% plant matter in diet	mostly insects when they are abundant; June and July	Kistchinski and Flint 1974
Population Density	$0.32/km^2$	average of three coastal sites	Derksen et al. 1981

As animals forage they may incidentally ingest soil and sediment particles. The average concentration of contaminants in soil/sediment can be multiplied by the amount of soil/sediment ingested to estimate the potential uptake of contaminants by this route. Soil intake rates have been reported for just a few wildlife species (Beyer et al. 1994). The soil ingestion rates for the representative species are extrapolated from Beyer et al. (1994) by using similar species with reported values. The percentages reported are of the total weight of dietary intake. Table 3-11 lists the representative bird species, the species used as surrogates, and the estimated percentages of soil ingested in quantifying exposure to contaminants. Species that forage directly in the soil or sediment, such as the sandpiper or goose, show relatively high percentages of soil in their diet. The Lapland longspur does not have appropriate surrogate species with soil ingestion data. Although the longspur is in the same foraging guild as sandpipers (which incidentally ingest relatively large amounts of soil), the longspur takes insects from the soil surface or gleans its prey from vegetation (Custer and Pitelka 1978), thus minimizing its soil intake. Its estimate of soil ingestion (less than two percent of diet by weight) reflects this. The glaucous gull ingests stones and sand as a mechanical addition (to aid in digestion) to its diet (Belopol'skii 1961), and this contributes to its soil/sediment intake. For those species without a suitable surrogate (i.e., Lapland longspur) or whose soil ingestion rate is reported as less than two percent, a value of two percent of dietary intake (by weight) was used to calculate the exposure estimates.

3.2.7.4 Exposure Assessment for Representative Species of Mammals. This section assesses exposure to contaminants for the selected representative species of mammals. Table 3-12 (brown lemming), Table 3-13 (arctic fox), and Table 3-14 (caribou) present life history data

TABLE 3-11. SOIL INGESTION ESTIMATES FOR REPRESENTATIVE BIRD SPECIES

REPRESENTATIVE SPECIES	SURROGATE SPECIES	ESTIMATED % OF SOIL IN DIET	ESTIMATED g/day SOIL IN DIET
Lapland longspur	no suitable surrogate	<2.0	0.1
Brant	Canada goose	8.2	5.7
Glaucous gull[a]	Siberian glaucous gull	7.6	5.6
Pectoral sandpiper	4 sandpiper species (average)	18.1	2.0
Spectacled eider	Canada goose	8.2	5.9

[a] Information from Belopol'skii 1961.
Source: Beyer et al. 1994.

TABLE 3-12. LIFE HISTORY INFORMATION FOR THE BROWN LEMMING, *Lemmus trimucronatus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	resident at all arctic coastal radar stations	dominant small mammal	USAF 1993
Habitat	tundra and alpine meadows	nests aboveground in winter, below in summer	Burt and Grossenheider 1976
Body Weight	55 g (0.055 kg)		Chappell 1980
Food Intake Rate	24-45 g/day dry matter	has low assimilation efficiencies (31-36%), variation also related to seasons	Chappell 1980
Water Intake Rate	0.007 liters/day	$WI=0.099(BWkg)^{0.90}$	Calder and Braun 1983
Diet Composition	sedges, grasses, lichens, roots, leaves, bark, berries		Nowak 1991
Home Range Size (AVG)	0.5 ha (females) 1.0 ha (males)	0.5 ha used in assessment	Nowak 1991
Population Density	0 to 325/ha	populations have large fluctuations on a 3-5 year cycle; currently populations are low	Nowak 1991; Snyder-Conn 1994

TABLE 3-13. LIFE HISTORY INFORMATION FOR THE ARCTIC FOX, *Alopex lagopus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	resident at all arctic coastal radar stations	ubiquitous	USAF 1993
Habitat	tundra and coastal plain	dens in sandy mounds >1 m high	Chesemore 1967
Body Weight	4950 g (4.95 kg)		Burt and Grossenheider 1976
Food Intake Rate	256 g/day dry matter	$FI=0.0687(BWkg)^{0.822}$	Nagy 1987
Water Intake Rate	0.42 liters/day	$WI=0.099(BWkg)^{0.90}$	Calder and Braun 1983
Diet Composition	brown lemming (summer), nesting birds, carrion, seal pups, non-food items	brown lemming in >85% of all scats, n=224	Chesemore 1967; Nowak 1991
Home Range Size (AVG)	20.8 km^2 adult 3.7 km^2 juvenile (<1 yr)	adult range used in assessment	Eberhardt et al. 1982

TABLE 3-14. LIFE HISTORY INFORMATION FOR THE BARREN-GROUND CARIBOU, *Rangifer tarandus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	seasonal at or near all arctic coastal radar stations	some sites used for calving	USAF 1993
Habitat	tundra in summer, open coniferous forest in winter	varies much, related to migration	Burt and Grossenheider 1976
Body Weight	95,500 g (95.5 kg)	mean for adults, m & f	Nowak 1991
Food Intake Rate	2400 g/day (2.4 kg) dry matter	$FI=0.0875(BWkg)^{0.727}$	Nagy 1987
Water Intake Rate	6.0 liters/day	$WI=0.099(BWkg)^{0.90}$	Calder and Braun 1983
Diet Composition	willows, sedges, cottongrass, lichens	selection based on plant phenology	Skogland 1980; White and Trudell 1980
Population Density	1.41 km^2	undisturbed calving area	Cameron et al. 1992
	0.31 km^2	within 1 km of road	
	4.53 km^2	within 5-6 km of road	

that are used to calculate exposure estimates for the representative species. Home range and/or population density has been listed for the representative mammal species, depending on appropriateness and availability.

Information on daily food intake rates for the arctic fox and caribou was not available. The rates have been estimated using regression equations associated with average body weights and metabolic rates (Nagy 1987). The food intake rates for the fox and caribou were estimated using the following equations, developed for placental mammals in general and for herbivorous mammals, respectively (Nagy 1987).

arctic fox: using equation for placental mammals in general

$$FI\ (\text{kg/day dry matter}) = 0.0687 \times (\text{body weight in kilograms})^{0.822}$$

caribou: using equation for mammalian herbivores

$$FI\ (\text{kg/day dry matter}) = 0.0875 \times (\text{body weight in kilograms})^{0.727}$$

Because of very low assimilation efficiencies, the low nutrient content of winter forage, and the high metabolic demands in arctic habitats (Chappell 1980), the equation for food intake rate significantly underestimates the rate for the brown lemming. A more appropriate rate for the brown lemming of 45 g/day is reported by Chappell (1980) (using the highest value in the reported range of 24-45 g/day).

The rates for water intake of the representative mammals were estimated using the equation generated by Calder and Braun (1983) because of the unavailability of species-specific information in the literature. The equation is:

$$WI\ (\text{liters/day}) = 0.099 \times (\text{body weight in kilograms})^{0.90}$$

Incidental soil intake was evaluated for mammals in the same manner as for birds (Section 3.2.7.3). Table 3-15 shows the percent of soil ingested for the representative mammal species.

3.3 ECOLOGICAL TOXICITY ASSESSMENT

This section presents toxicity information for each COC in surface water and soil/sediment. The COCs identified in surface water were DRPH and iron (Section 3.1.1). The COCs in soils/sediments are DRPH, GRPH, xylenes, naphthalene, 4-methylphenol, and PCBs. Sections 3.3.1 through 3.3.6 discuss the toxicity of all COCs to the receptor groups. Section 3.3.7 presents the methodology for the derivation of TRVs used for this ERA.

3.3.1 Petroleum Hydrocarbons

Section 3.1 presented the COCs for sites at the Bullen Point installation. DRPH were selected as a COC in surface water, and DRPH and GRPH were identified as COCs in soils/sediments. This section is a discussion of the chemical differences between DRPH, GRPH, and RRPH (although RRPH is not identified as a COC, it is included in the discussion because it is included

TABLE 3-15. SOIL INGESTION ESTIMATES FOR REPRESENTATIVE MAMMAL SPECIES

REPRESENTATIVE SPECIES	SURROGATE SPECIES	ESTIMATED PERCENT OF SOIL IN DIET	ESTIMATED g/day SOIL IN DIET
Brown Lemming	prairie dog	2.7	1.2
Arctic Fox	red fox	2.8	7.2
Caribou	elk	<2.0	48

Source: Beyer et al. 1994

in a measure of total petroleum hydrocarbons] (TPH) and the toxicity of these three petroleum mixtures.

Crude petroleum contains thousands of different chemical compounds. Gasoline and diesel fuel are refined petroleum products. The composition of gasoline and diesel fuel depends not only on the origin of the crude oil from which the gasoline is derived, but also the process technique and the blending scheme (Von Burg 1993). Once gasoline or diesel fuel is released to the environment, weathering and volatilization further alter its composition.

Gasoline is a complex, highly variable mixture of petroleum hydrocarbons containing 3 to 21 carbon atoms; however, compounds with 4 to 12 carbon atoms predominate. Gasoline is detected with the petroleum hydrocarbon analysis as GRPH. The following chemical classes are detected as GRPH: paraffins (straight-chained alkanes), olefins (straight-chained alkenes), naphthenes (cycloalkanes and alkenes), and aromatic hydrocarbons (alkylbenzenes and polynuclear) (VonBurg 1993). Although GRPH are generally in the range of 4 to 12 carbon atoms, the laboratory that conducted the analyses for Bullen Point detected GRPH with 6 to 9 carbon atoms. As many as 140 compounds have been identified as constituents of gasoline; however, a small number of constituents such as benzene drive the toxicity. Diesel fuel is also a complex, variable mixture of the same classes of compounds containing 6 to 21 carbon atoms. Diesel fuel is detected with petroleum hydrocarbon analysis as DRPH. The laboratory that analyzed samples for Bullen Point detected DRPH with 10 to 24 carbons atoms. As many as 45 compounds have been identified as constituents of diesel fuel (Von Burg 1993). RRPH could include many different types of chemicals, although the majority of molecules would include 24 carbon atoms or more.

Table 3-16 presents the chemical classes and weight percent for GRPH and DRPH. Generally, gasoline contains more aromatic compounds and simple-chained alkanes, whereas diesel fuel is characterized by cycloparaffins (or cycloalkanes). Both gasoline and diesel fuel will be affected by the environment. Weathering will change the chemical composition of petroleum, and concentrations of aromatic compounds such as benzene will decrease as a result of volatilization.

TABLE 3-16. CHEMICAL CLASSES OF GRPH AND DRPH

CHEMICAL CLASS	WEIGHT PERCENT[a]
GRPH[b]	
Normal paraffins (n-alkanes)	19.3-38.4 (28.8)
Isoparaffins (isoalkanes)	11.5-50.3 (30.9)
Naphthenes (cycloparaffins or cycloalkanes)	1.0-2.8 (1.9)
Aromatics (e.g., benzene, toluene, pyrene)	9.7-54.7 (32.2)
DRPH[c]	
Normal paraffins (n-alkanes)	5.6
Isoparaffins (isoalkanes)	11.1
Naphthenes (cycloparaffins or cycloalkanes)	46.3
Aromatics (e.g., benzene, toluene, pyrene)	33.3
Nitrogen, sulfur and oxygen compounds	3.7

a Average shown in parentheses.
b Heath et al. 1993.
c Weeks et al. 1988.

Available toxicity test data have been derived from pure, fresh product, and therefore the applicability to the weathered product encountered at Bullen Point is uncertain. Gasoline is the most studied of the petroleum products; however, most data are based on inhalation studies. Gasoline was classified by EPA (1992b) as a Group C (possible human) carcinogen, whereas diesel oil was classified as Group D (not classifiable as to human carcinogenicity). Presumably, this classification of gasoline is due to benzene which, under the conditions of environmental exposure, would volatilize more rapidly than any other constituent. The gasoline and diesel petroleum hydrocarbon data from surface water samples collected at Bullen Point indicate that benzene was not detected in surface water and the soil/sediment samples showed concentrations below action levels. Physical-chemical data from the literature indicates that TPH in soil would reflect all constituents with eventual loss of aromatic (e.g., BTEX) components first, lighter alkanes second, lighter polynuclear aromatic hydrocarbons (PAHs) third, followed by naphthalenes. For an old diesel or petroleum spill, TPH measurements may reflect predominantly trace amounts of high molecular-weight PAHs or higher molecular-weight and branched alkanes [Massachusetts Department of Environmental Protection (MDEP) 1993].

For the purposes of ranking the toxicity of GRPH, DRPH, and RRPH, it is assumed that BTEX and lighter-weight alkanes were significantly weathered from exposure to the arctic environment, and that toxicity is more dependent upon noncarcinogenic endpoints associated with alkanes, alkenes, and cycloalkanes. In addition, the toxicity of DRPH and RRPH is associated with the PAH content. However, at Bullen Point, the only two PAHs were detected: naphthalene and 2-methylnaphthalene, chemicals considered to be noncarcinogenic. Other carcinogenic PAHs such as benzo(a)pyrene were not detected. MDEP (1993) reviewed the noncarcinogenic toxicological endpoints in laboratory animals for diesel fuel and gasoline and determined that diesel fuel was an order of magnitude more toxic than gasoline, although other sources indicate that the toxicity of alkanes and cycloalkanes is similar (Armstrong Laboratory 1994; Sax and Lewis 1989). A review of the Bullen Point data indicates that DRPH are present at higher concentrations than either GRPH or RRPH. Specifically, average concentrations of DRPH were approximately 10 times higher than average concentrations of GRPH. As a result, based on the MDEP review and the chemical data reported for the Bullen Point surface water and soil/sediment samples, DRPH are evaluated and used to represent conservatively ecological risks from petroleum hydrocarbon contamination (i.e., GRPH, RRPH, and other constituent chemicals, such as 2-methylnaphthalene).

As discussed above, diesel fuel is comprised of a complex mixture of paraffins (straight-chained alkanes), olefins (straight-chained alkenes), naphthenes (cycloalkanes and alkenes), and aromatic (alkylbenzenes, and polynuclear) petroleum hydrocarbons containing 6 to 21 carbon atoms. Hydrocarbons containing 8 to 18 carbon atoms predominate (Von Burg 1993). There are six grades of diesel fuel (Diesel Oil No. 1, Diesel Oil No. 2, Diesel Oil No. 4, Fuel Oil No. 1, Fuel Oil No. 2, and Home Heating Oil) (Von Burg 1993). The specific components of diesel are expected to change from source to source, so the toxicity of diesel fuels is expected to be variable. The following sections summarize the toxicity of diesel fuel to plants, aquatic organisms, birds, and mammals.

3.3.1.1 Plants. Petroleum released to the aquatic environment is expected to be toxic to aquatic plants. Toxicity tests have shown that the water-soluble components of petroleum are toxic to an algal species (*Chlorella vulgaris*) (Kauss and Hutchinson 1975). However, in this specific study, the toxicity was short term. The algal community recovered after a "lag phase". It was theorized (Kauss and Hutchinson 1975) that this trend was due to the loss of highly volatile fractions from the testing chamber over time. Exposure to water extracts of No. 2 Fuel Oil depressed algal biomass in communities and resulted in blue-green algal dominance and decreased diatom occurrence (Bott and Rogenmuser 1978).

3.3.1.2 Aquatic Organisms. Moles et al. (1979) tested the acute toxicity of Prudhoe Bay crude oil to several Alaskan freshwater and anadromous fish. Salmonids were the most sensitive species tested, and demonstrated median tolerance limits (the concentration at which one half the organisms survive in 96 hours, same as LC_{50} [lethal concentration for 50 percent of the organisms]) ranging from 2.7 to 4.4 mg/L. The three-spined stickleback, *Gasterosteus aculeatus*, was more tolerant, with an LC_{50} of 10.4 mg/L. Klein and Jenkins (1983) studied the toxicity of the water soluble fraction of jet fuel to fish. Growth of fry was retarded by 1.5 mg/L of the water soluble fraction of JP-8 (jet fuel with de-icer). In a study conducted by Hedtke and Puglisi (1982), the method of introducing the oil to the test chamber was an important variable driving toxicity.

Emulsified oils were substantially more toxic than either floating oils or the water soluble fraction. The 96-hour LC_{50} for fathead minnows (*Pimephales promelas*) exposed to the emulsion of No. 2 jet fuel was 38.6 mg/L (concentration used to calculate the TRV).

Aquatic organisms other than fish may also be exposed to diesel fuel in the environment. Studies have shown that freshwater arctic zooplankton may be more sensitive to oil pollution than any other arctic freshwater organisms (O'Brien 1978). Geiger and Buikema (1981) estimated an LC_{20} (concentration lethal to 20 percent of the test organisms) of No. 2 Fuel oil to *Daphnia pulex* of 5.6 mg/L (concentration used to calculate TRV).

3.3.1.3 Birds. Petroleum hydrocarbons in the environment may affect bird reproduction. External application of Number 2 fuel oil to mallard (*Anas platyrhynchos*) and common eider (*Somateria mollissima*) eggs significantly increased embryo mortality (Albers 1977; Szaro and Albers 1977). Mallard eggs were treated with 1, 5, 10, 20, and 50 µl of fuel oil. Ingestion of crude oil by mallards at a concentration of five percent by weight in the diet resulted in depressed growth (Szaro et al. 1978). Hartung (1964) demonstrated a decrease in weight gain in mallards during the first 10 days after receiving 6,000 mg/kg No. 2 fuel oil (concentration used to calculate TRV). However, after 34 days there was no difference between treatment groups and the controls.

3.3.1.4 Mammals. The available literature does not present a great deal of information regarding the toxicity of diesel fuel to mammals. The toxicity of diesel fuel to mammals can be represented by the toxicity of the compound to rats. Diesel fuel is relatively nontoxic to rats based on an acute oral LD_{50} (lethal dose for 50 percent of the organisms) of 7,380 mg/kg (Beck et al. 1982) (dose used to calculate TRV). A dermal LD_{50} in rabbits was reported as >4,290 mg/kg (Beck et al. 1982).

3.3.2 Xylene

Xylene is a COC in soil/sediment at the Bullen Point installation. It is a VOC, and most toxicity information in the literature relates to the inhalation of xylene. A summary of the relevant information is presented below.

3.3.2.1 Plants. In a study of the green algae, *Selenastrum capricornutum*, xylene decreased growth at concentrations of 72,000 µg/L (Gaur 1988 in AQUIRE 1990).

3.3.2.2 Aquatic Organisms. Xylene is not a COC in surface water, so the toxicity to aquatic organisms is not presented.

3.3.2.3 Birds. When mallard eggs were immersed in xylene (1 and 10 percent) for 30 seconds, there was no significant effect at concentrations of 10 percent on embryonic weight and length when compared to controls [Hoffman and Eastin 1981 in Hazardous Substance Data Bank (HSDB) 1994]. Japanese quail (*Coturnix japonica*) fed xylene demonstrated no sign of toxicity up to 5,000 ppm (Hill and Camardese 1986)). The LC_{50} was >20,000 ppm (Hill and Camardese 1986). Hill and Camardese (1986) report a maximum dietary exposure level for Japanese quail of 625 mg/kg total xylenes (dose used to calculate TRV).

3.3.2.4 Mammals. Ingestion of xylene in mammals may cause prenatal mortality, growth inhibition, and malformations, primarily cleft palate. The LD_{50} for ingestion of xylene (rat) was reported as 4,300 mg/kg (Clayton and Clayton 1981) (dose used to calculate TRV).

3.3.3 Naphthalene

Naphthalene was determined to be a COC in soil/sediment, but not in surface water. Naphthalene belongs to the group of chemical compounds known as PAHs. PAHs are hydrogen and carbon atoms combined to form two or more fused benzene rings (Eisler 1987). The structure of naphthalene is a two-ring, unsubstituted molecule ($C_{10}H_8$). Specific toxicity data for naphthalene is generally lacking, so the following discussion may include toxicity information for other PAH compounds.

3.3.3.1 Plants. Specific toxicity information for plants exposed to naphthalene or other PAHs is not available. Some general trends have been observed by researchers (EPA 1980; Lee and Grant 1981; Wang and Meresz 1982; Edwards 1983; Sims and Overcash 1983 in Eisler 1987). PAHs may be absorbed from soil through plant roots and can be translocated to other parts of the plant. The factors that appear to govern plant uptake include soil concentration, water solubility, and soil type.

3.3.3.2 Aquatic Organisms. Naphthalene was not selected as a COC in water, so it is not quantitatively evaluated in terms of exposure of aquatic organisms.

3.3.3.3 Birds. There is limited information regarding the toxicity of PAHs to birds. In a study conducted by Patton and Dieter (1980), mallards fed 4,000 mg PAHs/kg for 7 months demonstrated increased liver weight and blood flow to the liver. The PAH mixture tested contained naphthalenes, naphthenes, and phenanthrene. A TRV for naphthalene was not extrapolated from this PAH data because the date were not specific to naphthalene.

3.3.3.4 Mammals. Some PAHs are animal carcinogens. However, unsubstituted PAHs with fewer than four rings (as is naphthalene) have not been shown to induce tumorigenic activity (Eisler 1987). In addition, although unsubstituted PAHs are highly lipid soluble, they do not accumulate in mammalian tissue because of ready metabolization by animals (EPA 1980; Lee and Grant 1981). Specific studies regarding the toxicity of naphthalene to mammals are limited. It has been reported that 1,780 mg/kg body weight of naphthalene caused acute oral toxicity in rats (Sims and Overcash 1983 in Eisler 1987). The Hazardous Substance Data Bank (HSDB 1994) reports a NOAEL dose of 50 mg/kg naphthalene (dose used to calculate TRV) for a laboratory rat.

3.3.4 4-Methylphenol

4-Methylphenol (C_7H_8O) is a COC in soil/sediment. It was detected in one sediment sample collected from the Old Landfill/Dump Site East (LF06) at a concentration of 0.58 mg/kg. 4-Methylphenol is also known as p-cresol. Cresols are present in natural and man made products such as wood and tobacco smoke, crude oil, coal tar, disinfectants, and deodorizers (ATSDR 1991). Natural cresols are constantly released to soils via excrement/exocellular

secretions and decay of organisms (ATSDR 1991). Cresols break down rapidly when released to the environment. Under aerobic conditions in soil the half life is expected to be on the order of weeks. This process is likely to be similar in sediments (ATSDR 1991). When released to surface waters, cresols are also expected to degrade rapidly (ATSDR 1991). The following section presents toxicity information for 4-methylphenol.

3.3.4.1 Plants. There is no information available regarding the toxicity of 4-methylphenol to plants.

3.3.4.2 Aquatic Organisms. 4-Methylphenol was not found to be a COC in water, so it is not quantitatively evaluated in terms of exposure of aquatic organisms.

3.3.4.3 Birds. There is no information available concerning the toxicity of 4-methylphenol to birds.

3.3.4.4 Mammals. There is limited information regarding the toxicity of 4-methylphenol to mammals. In acute studies, researchers derived an LD_{50} of 2,020 mg/kg/day for the rat (ATSDR 1991). Other studies determined NOAELs for respiratory and hepatic effects of 175 and 450 mg/kg/day, respectively. The TRV used in this risk assessment is based on an LD_{50} for rat (oral exposure) of 207 mg/kg/day (Sax and Lewis 1989).

3.3.5 Polychlorinated Biphenyls

PCBs were determined to be COCs in soil/sediment at the Bullen Point installation. PCBs are organic compounds produced commercially by the chlorination of a biphenyl molecule (Eisler 1986). Depending upon the average degree of chlorination, the PCBs are grouped into seven Aroclor groups, each with varying toxicity. Aroclor is the trade name for PCBs produced in the U.S. The four digit number following Aroclor usually begins with 12 for biphenyl, and ends with two digits expressing the average percentage by weight of chlorine. Thus Aroclor 1254 is 54 percent chlorine by weight while Aroclor 1260 is 60 percent chlorine by weight. Usually the more chlorinated Aroclors (1254 and 1260) are more toxic than lesser chlorinated Aroclor (1232 or 1242). The group of PCBs detected at the Bullen Point installation was Aroclor 1254. PCBs are very stable in the environment, slow to degrade, and bioaccumulative. The following sections summarize the toxicity of PCBs.

3.3.5.1 Plants. Very little toxicity information for plants is available in the literature. However, PCBs may inhibit photosynthesis and cell motility in phytoplankton (Eisler 1986). In addition, aquatic plants may provide a route of exposure into the aquatic food chain. An increase (five times) in somatic mutations was noted in terrestrial plants growing on sediments containing mean PCB residues of 26 mg/kg (predominantly Aroclor 1254) (Eisler 1986).

3.3.5.2 Aquatic Organisms. PCBs were not found to be a COC in water, so they are not quantitatively evaluated in terms of exposure of aquatic organisms.

3.3.5.3 Birds. PCBs are expected to disrupt patterns of growth, reproduction, metabolism, and behavior in sensitive avian species (Eisler 1986). Mourning doves (*Zanaida*

macroura carolinensis) that were fed Aroclor 1254 for 6 weeks exhibited abnormal courtship behavior and reproductive efforts. The tested concentrations were 10 or 40 ppm. The researchers suggested that the disrupted reproductive behavior was due to reduced hormone levels (Tori and Peterle 1983 in Eisler 1986). No reproductive effects were observed in mallards (*Anas platyrhynchos*) exposed to 150 ppm (mg/kg feed) Aroclor 1252 in the diet for 12 weeks during egg laying (Haseltine and Prouty 1980), or in mallards exposed to 25 ppm Aroclor 1254 in the diet for at least a month before egg laying (Custer and Heinz 1980).

3.3.5.4 Mammals. Reproductive toxicity following chronic or subchronic exposures appears to be the most sensitive toxic endpoint of PCBs exposure in mammals. Mink (*Mustela vison*) are particularly susceptible to reproductive effects of PCBs. Mink fed contaminated beef (Aroclor 1254) developed reproductive complications at dietary residue levels as low as 0.64 ppm (Platanow and Karstad 1973). A dietary level LC_{50} of 6.7 ppm was reported for an exposure period of 9 months for Aroclor 1254 (Ringer 1983). Other species may be less sensitive to the toxic effect of PCBs. White-footed mice (*Peromyscus leucopus*) exposed to PCBs at a concentration of 10 ppm in the diet through the second generation exhibited poor reproductive success, and growth and development of organs, but no increased mortality (Linzey 1988).

3.3.6 Iron

Iron is an essential trace element required by both plants and animals. It is a COC in surface water at the Bullen Point installation.

3.3.6.1 Plants. In a study conducted by Foy et al. (1978 in EPA 1985), concentrations of 100 to 500 ppm soluble iron in soil were toxic to rice.

3.3.6.2 Aquatic Organisms. Iron may be a threat in aquatic environments in the form of precipitates that can destroy habitat, coat gills, and inhibit oxygen uptake. The EPA uses 1,000 μg/L as the chronic AWQC protective of aquatic life (dose used to calculate TRV) (EPA 1986c). In a study conducted by Warnick and Bell (1969 in EPA 1976) mayflies, stoneflies, and caddisflies were affected by iron concentrations of 320 μg/L (96-hr LC_{50}). Doudoroff and Katz (1953 in EPA 1976) found iron concentrations of 1,000 to 2,000 μg/L toxic to *Esox lucius* (northern pike) and trout (species not reported).

3.3.6.3 Birds. There are few studies available that address the toxicity of iron to species of wild birds. There was no adverse effect produced in turkeys at concentrations of 440 ppm (Woerpel and Balloun 1964 in NAS 1980). NAS (1980) recommends that the maximum tolerable level of dietary iron of 1,000 ppm be used for poultry. The 1,000 ppm dose converts to 70.0 mg/kg for a maximum tolerable dietary level for a chicken (dose used to calculate TRV).

3.3.6.4 Mammals. At high concentrations, iron is toxic to livestock and interferes with phosphorus metabolism (NAS 1974 in EPA 1976). Cattle fed 477 μg/g iron demonstrated a slight decrease in weight gain; concentrations of 1,677 μg/g of iron produced a significant decline in growth rate (EPA 1985). Shanas and Boyd (1969 in NAS 1980) report an acute LD_{50} dose of iron for the rat to be 1,000 mg/kg (dose used to calculate TRV for brown lemming and arctic fox).

The maximum tolerable dietary level of 500 ppm of iron for sheep is used to calculate the TRV for caribou (NAS 1980).

3.3.7 Characterization of Effects

In this section toxicity information is presented for representative ecological receptors evaluated in the risk characterization section of this report (Section 3.4). Potential impacts to aquatic receptors are evaluated by comparing exposure concentrations to TRVs. Potential impacts to terrestrial wildlife are evaluated for the representative species based on comparisons of estimated exposures to TRVs. TRVs for the representative aquatic species are presented in Table 3-17. Exposure to COCs for the representative species is primarily through diet; which may include plants, fish, aquatic invertebrates, soils, and surface water. TRVs are derived for COCs in surface water and soil/sediment. TRVs for the representative bird species are presented in Tables 3-18 and 3-19, for the representative mammal species in Table 3-20, and for threatened species in Table 3-21.

3.3.7.1 Toxicity Reference Values. TRVs were derived by selecting toxicity values from the literature and extrapolating to the species of concern. UF and body scaling factors were used in the extrapolation process as described below.

(1) The first step was to select an appropriate toxicity value from the scientific literature for each combination of chemical and representative or protected species. Test species most similar to the species of concern were preferred. A secondary emphasis was given to tests conducted over a significant portion of the animal's natural lifespan (e.g., chronic tests) when available.

(2) The second step was to modify the toxicity value, if necessary, through application of uncertainty factors associated with the quality of toxicity data to derive a NOAEL (the highest concentration of a material in a toxicity test that has no statistically significant adverse effect on the exposed population of test organisms as compared with the next highest dose tested). If a chronic NOAEL or No Observed Effect Level (NOEL) was available, then the toxicity value was used with an uncertainty factor of one (i.e., no adjustment) because these values have the lowest uncertainty. If chronic data were unavailable, acute or subchronic toxicity data were modified by uncertainty factors to extrapolate to chronic effects. Based on Harding Lawson Associates (1992), the following strategy was derived for uncertainty factors for extrapolating study results to chronic NOAELs: 10 for chronic LOEL values, 10 for subchronic NOEL values, and 20 for subchronic LOEL values. LC_{50} and LD_{50} values are extrapolated to chronic NOAELs by a factor of 20.

(3) The third step applies only to terrestrial receptors. This step extrapolates the estimated NOAEL from the test species to a NOAEL for the species of concern using a body scaling factor. Klaassen et al. (1986) have indicated that dose expressed on a per unit surface area basis may be more appropriate than dose per unit body weight. The underlying assumption is that a toxicant acts on a

TABLE 3-17. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF AQUATIC ORGANISMS AT THE BULLEN POINT INSTALLATION

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	CONCENTRATION (μg/L)	TEST SPECIES	NOAEL UF	INTERSPECIES UF	PROTECTED SPECIES UF	TRV (μg/L)	REFERENCE
DRPH	arctic char	LC_{50}	38,600	fathead minnow	20	2	1	965	Hedtke and Puglisis 1982
	nine-spined stickleback	LC_{50}	38,600	fathead minnow	20	2	1	965	Hedtke and Puglisis 1982
	Daphnia spp.	LOAEL	5,600	*D. pulex*	20	1	1	280	Hedtke and Puglisis 1982
Iron	arctic char	EPA chronic water quality criteria	1,000	all aquatic life	1	1	1	1,000	EPA 1986c
	nine-spined stickleback	EPA chronic water quality criteria	1,000	all aquatic life	1	1	1	1,000	EPA 1986c
	Daphnia spp.	EPA chronic water quality criteria	1,000	all aquatic life	1	1	1	1,000	EPA 1986c

TABLE 3-18. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF BIRDS AT THE BULLEN POINT INSTALLATION (METALS)

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
Iron	Lapland longspur	NOAEL; 28 day growth study	70.0	chicken	1	0.32	2	2	54.7	McGhee et al. 1965 in NAS 1980
	brant	NOAEL; 28 day growth study	70.0	chicken	1	1.18	2	2	14.8	McGhee et al. 1965 in NAS 1980
	glaucous gull	NOAEL; 28 day growth study	70.0	chicken	1	1.22	2	2	14.3	McGhee et al. 1965 in NAS 1980
	pectoral sandpiper	NOAEL; 28 day growth study	70.0	chicken	1	0.46	2	2	38.0	McGhee et al. 1965 in NAS 1980

TABLE 3-19. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF BIRDS AT THE BULLEN POINT INSTALLATION (ORGANICS)

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
DRPH	Lapland longspur	decreased weight gain LOAEL	6,000	mallard	10	0.29	2	2	517	Hartung 1964
	brant	decreased weight gain LOAEL	6,000	mallard	10	1.07	2	2	140	Hartung 1964
	glaucous gull	decreased weight gain LOAEL	6,000	mallard	10	1.10	2	2	136	Hartung 1964
	pectoral sandpiper	decreased weight gain LOAEL	6,000	mallard	10	0.42	2	2	357	Hartung 1964
Xylene	Lapland longspur	Maximum dietary exposure	608	Japanese quail	10	0.60	2	2	25	Hill and Camardese 1986
	brant	Maximum dietary exposure	608	Japanese quail	10	2.16	2	2	7	Hill and Camardese 1986
	glaucous gull	Maximum dietary exposure	608	Japanese quail	10	2.23	2	2	7	Hill and Camardese 1986
	pectoral sandpiper	Maximum dietary exposure	608	Japanese quail	10	0.85	2	2	18	Hill and Camardese 1986
Naphthalene	No avian toxicity data available for naphthalene; see discussion in Section 3.4.3, Potential Risks to Representative Species of Birds.									
4-Methylphenol	No avian toxicity data available for methylphenol; see discussion in Section 3.4.3, Potential Risks to Representative Species of Birds.									
PCBs	Lapland longspur	LD_{50}	2,699	Mallard	20	0.29	2	2	116	Heath et al. 1972

TABLE 3-19. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF BIRDS AT THE BULLEN POINT INSTALLATION (ORGANICS) (CONTINUED)

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
PCBs (Continued)	brant	LD_{50}	2,699	Mallard	20	1.07	2	2	32	Heath et al. 1972
	glaucous gull	LD_{50}	2,699	Mallard	20	1.1	2	2	31	Heath et al. 1972
	pectoral sandpiper	LD_{50}	2,699	Mallard	20	0.42	2	2	80	Heath et al. 1972

TABLE 3-20. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF MAMMALS AT THE BULLEN POINT INSTALLATION

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
DRPH	brown lemming	LD_{50}	7,380	rat	20	0.60	2	1	308	Beck et al. 1982
	arctic fox	LD_{50}	7,380	rat	20	2.70	2	1	68	Beck et al. 1982
	caribou	LD_{50}	7,380	rat	20	7.24	2	1	25	Beck et al. 1982
Xylenes (total)	brown lemming	LD_{50}	4,300	rat	20	0.60	2	1	179	Clayton and Clayton 1981
	arctic fox	LD_{50}	4,300	rat	20	2.70	2	1	40	Clayton and Clayton 1981
	caribou	LD_{50}	4,300	rat	20	7.24	2	1	15	Clayton and Clayton 1981
Naphthalene	brown lemming	NOAEL	50	rat	1	0.60	2	1	42	HSDB 1994
	arctic fox	NOAEL	50	rat	1	2.70	2	1	9.3	HSDB 1994
	caribou	NOAEL	50	rat	1	7.24	2	1	3.5	HSDB 1994
4-Methylphenol	brown lemming	LD_{50}	207	rat	20	0.60	2	1	8.6	Sax and Lewis 1989
	arctic fox	LD_{50}	207	rat	20	2.70	2	1	1.9	Sax and Lewis 1989
	caribou	LD_{50}	207	rat	20	7.24	2	1	0.7	Sax and Lewis 1989
PCBs	brown lemming	LD_{50}	75	rat	20	0.60	2	1	3.1	Hudson et al. 1984
	arctic fox	LD_{50}	75	rat	20	2.70	2	1	0.7	Hudson et al. 1984
	caribou	LD_{50}	75	rat	20	7.24	2	1	0.3	Hudson et al. 1984
INORGANICS										
Iron	brown lemming	Acute LD_{50}	1,000	rat	20	0.60	2	1	42	Shanas and Boyd 1969 in NAS 1980
	arctic fox	Acute LD_{50}	1,000	rat	20	2.70	2	1	9.3	Shanas and Boyd 1969 in NAS 1980
	caribou	NOAEL; maximum tolerable dietary level	20	sheep	1	1.17	2	1	8.5	NAS 1980

TABLE 3-21. TOXICITY REFERENCE VALUES FOR ENDANGERED AND THREATENED SPECIES AT THE BULLEN POINT INSTALLATION

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
Iron	spectacled eider	NOAEL; 28 day growth study	70	chicken	1	1.2	2	2	15	McGhee et al. 1965 in NAS 1980
DRPH	spectacled eider	decreased weight gain LOAEL	6,000	mallard	10	1.08	2	2	139	Hartung 1964
Xylene	spectacled eider	Maximum dietary exposure	608	Japanese quail	10	2.39	2	2	6	Hill and Camardese 1986
Naphthalene	No avian toxicity data available for naphthalene; see discussion in Section 3.4.3, Potential Risks to Representative Species of Birds.									
4-Methylphenol	No avian toxicity data available for 4-methylphenol; see discussion in Section 3.4.3, Potential Risks to Representative Species of Birds.									
PCBs	spectacled eider	LD_{50}	2,699	mallard	20	1.08	2	2	31	Heath et al. 1972

physiologic surface and that the toxic effect increases as the ratio of chemical to surface area increases. The SF accounts for differences in the mass to surface area ratios between species. In this assessment the scaling factor was calculated using the following equation (Mantel and Schneiderman 1975) (scaling factors are presented in Appendix F):

SF = (weight of representative species/weight of test species)$^{1/3}$.

(4) An uncertainty factor of 2 was used to account for interspecies variation in sensitivity. This value is based on the methodology used by Harding Lawson Associates (1992).

(5) An uncertainty factor of 2 was used to account for additional sensitivity of state and/or federally protected species. This value is based on Harding Lawson Associates (1992). Migratory birds are federally protected and include all the representative avian and protected species selected for this assessment.

The methods of calculating the TRV for the terrestrial and aquatic receptors are as follows:

TERRESTRIAL:

a) Convert test dose to a NOAEL:
DOSE ÷ **NOAEL UF** = Estimated NOAEL

b) Adjust for body size difference between test species and ROC:
Estimated NOAEL ÷ **SCALING FACTOR** = Scaled, estimated NOAEL

c) Adjust for interspecific differences:
Scaled, estimated NOAEL ÷ **INTERSPECIES UF** = Species-specific, scaled, estimated NOAEL.

d) Account for protected species status:
Species-specific, scaled, estimated NOAEL ÷ **PROTECTED SPECIES UF** = **TRV**

AQUATIC:
EFFECTIVE CONCENTRATION ÷ **NOAEL UF** ÷ **INTERSPECIES UF** = **TRV**

3.4 RISK CHARACTERIZATION FOR ECOLOGICAL RECEPTORS

In this section, potential risks to ecological receptors (representative species) are presented. Potential risks to plants were evaluated based on the contaminant concentrations in the soil/sediment and information from the literature. Potential risks to aquatic organisms, birds, and mammals were estimated by comparing estimated exposures to TRVs (i.e., quotient method). The quotient method divides the estimated exposure concentration by the associated TRV to derive the HQ. If the HQ is less than 1.0, then adverse effects are not expected. Conversely, if

the HQ is equal to or greater than 1.0 a potential for adverse effects exists. The confidence level of the risk estimate is increased as the magnitude of the HQ departs from 1.0. For example, there is greater confidence in a risk estimate where the HQ is 0.1 or 10, than in a HQ such as 0.9 or 1.1. The confidence level is also dependent on the uncertainty associated with the estimated exposure and the TRV for a given chemical-receptor combination.

The characterization of risk focuses on the assessment endpoints. These endpoints were selected and discussed in keeping with the Framework for Ecological Risk Assessment guidance (EPA 1992a). The assessment endpoints for the Bullen Point ERA are changes in:

- the populations of the plant representative species (*Carex* spp., *Salix* spp., *Eriophorum* spp., and *Vaccinium* spp.);
- the populations of aquatic representative species (*Daphnia* spp., nine-spined stickleback, and arctic char);
- the populations of avian representative and sensitive species (Lapland longspur, brant, glaucous gull, pectoral sandpiper, and spectacled eider); and
- the populations of mammalian representative species (brown lemming, arctic fox, and barren-ground caribou).

The measurement endpoints used to evaluate potential changes in populations of the representative species were based on the endpoints used to derive the TRVs. These endpoints included growth, reproduction, and mortality.

Potential ecological risks are presented in the following sections: Section 3.4.1 addresses representative species of plants; Section 3.4.2 considers aquatic organisms; Section 3.4.3 addresses representative species of birds; and Section 3.4.4 discusses representative species of mammals. A discussion of potential future risks to ecological receptors is presented in Section 3.4.5. The HQs that represent potential risk estimates are summarized in tables presented in Section 3.4.3.

3.4.1 Potential Risks to Representative Species of Plants

In determining the risks to plants at the Bullen Point installation, a qualitative comparison was made of soil and surface water contaminant concentrations and plant toxicity information in the literature. Table 3-22 summarizes these comparisons. Little information is available regarding the toxicity of the Bullen Point COCs in soil/sediment, although the organic COCs are less bioavailable in soil/sediment than COCs in surface waters. There is a great deal of uncertainty in this phase of the assessment because of the differences in degree of uptake between plant species (Walker et al. 1978). However, the concentrations of contaminants onsite can be compared on the level of orders of magnitude. This comparison allows broad trends to be observed in order to determine whether a potential risk may exist.

TABLE 3-22. COMPARISON OF CONCENTRATIONS OF POTENTIAL CONTAMINANTS TO TOXICITY INFORMATION FOR PLANTS AT THE BULLEN POINT INSTALLATION

CHEMICAL (COC media)	PLANT	EXPOSURE LEVEL	EFFECT ON PLANT	BULLEN POINT EXPOSURE	REFERENCE
IRON (COC in water)	rice	100,000-500,000 μg/L >500,000 μg/L	toxic; highly toxic	2,900 μg/L	Foy et al. in EPA 1985
VOCs (COC in soil)	green algae	4,600 μg/L for ethylbenzene 2,290 μg/L for methylene chloride, in water	EC_{50}	890 μg/L as DRPH	USACOE 1991
PCBs (Aroclor 1254) (COC in soil)	pigweed	40 mg/kg 20 mg/kg	22% weight reduction NOAEL	0.1 mg/kg	Strek and Weber 1982 in Will and Suter 1994

Information is generally lacking concerning the toxicity of the COCs at Bullen Point and how COCs relate to the representative species of plants. As a result, when comparisons of TRVs for site-specific species and chemicals are not possible, comparisons of related chemicals with other plant species are made. As seen in Table 3-22, the concentrations of iron found in the surface water at Bullen Point are about 30 times lower than reported toxicity values. In addition, the concentrations of VOCs at the site are substantially lower than toxicity values reported by Galassi et al. (1988 in USACOE 1991) and Hutchinson et al. (1980 in USACOE 1991) and listed in Table 3-22. These VOCs are not expected to be present at significant levels in most plants because of their volatility, absorption to soil particles, metabolism, and degradation rates in soil (Kostecki and Calabrese 1989).

The comparisons presented in Table 3-22 are not definitive in judging the toxicity of metals to the specific representative plant species; however, noting the differences between exposure concentrations that pose risks and the concentrations at the installation, risks to *Carex*, *Salix*, *Eriophorum*, and *Vaccinium* spp. are not likely to be significant.

3.4.2 Potential Risks to Representative Species of Aquatic Organisms

Estimates of exposure for aquatic organisms were based on the average concentrations of COCs in surface water samples (Section 3.1). The TRVs for aquatic species are presented in Table 3-17. The HQs are calculated by dividing the estimated exposure concentration by the TRV. Table 3-23 presents the results of the risk characterization for aquatic organisms. The following paragraph summarizes the potential risks to aquatic organisms from iron and DRPH, the COCs identified in surface water.

TABLE 3-23. RISK CHARACTERIZATION OF REPRESENTATIVE SPECIES OF AQUATIC ORGANISMS AT THE BULLEN POINT INSTALLATION

SPECIES	ESTIMATED EXPOSURE CONCENTRATION (μg/liter)	TRV (μg/liter)	HAZARD QUOTIENT
DRPH			
Daphnia spp.	890	965	0.9
nine-spined stickleback	890	965	0.9
arctic char	890	280	3.2
IRON			
Daphnia spp.	2,900	1,000	2.9
nine-spined stickleback	2,900	1,000	2.9
arctic char	2,900	1,000	2.9

The HQs for iron in surface water were 2.9 for *Daphnia* ssp., nine-spined stickleback, and arctic char. These HQs indicate that a potential risk to aquatic organisms exists from iron concentrations in surface water. These risks are mitigated, however, by the fact that "total" metal concentrations were used to estimate risk. The HQs are based on total concentrations of iron (i.e., 2,900 μg/L), while the dissolved concentrations of 120 μg/L do not pose risks to any of the aquatic representative species. In addition, the site-specific risks are likely lower than the risk estimates presented for the nine-spined stickleback and arctic char, due to the nature of the drainage areas at the installation. The surface water samples collected from the Old Landfill/Dump Site East, where the elevated iron concentrations were located, are not likely significant routes of exposure for the nine-spined stickleback, as they are collected from shallow ephemeral ponds that freeze to the bottom in the winter. In addition, there does not appear to be a complete exposure pathway for the anadromous arctic char because the surface water samples are not directly connected to marine waters.

The DRPH for *Daphnia* spp. was 3.2. Although this indicates a potential risk to *Daphnia*, the estimated exposure concentration of 89 μg/L is based on the average of five surface water samples. These samples were taken from likely "hot spots". While DRPH may pose a risk to *Daphnia* are these particular locations, it is not likely that the population of *Daphnia* is at risk from DRPH over the entire Bullen Point installation.

Based on the available data and the mitigating factors discussed above, the risk to aquatic organisms from COCs at the Bullen Point installation is low.

3.4.3 Potential Risks to Representative Species of Birds

The HQs for all COCs were below 1.0 for all species of birds evaluated (see Table 3-24). As a result, the risks to avian species at Bullen Point are not estimated to be significant. Some important factors should be considered when reviewing these risk estimates. For example, it is important to note that a portion of the birds' diets (i.e., invertebrates) was not quantified in this assessment. This may result in an underestimate of potential exposure to metals, although iron, the only metal identified as a COC, is not expected to bioaccumulate to levels that would pose any risk to birds. Because metals were not a concern at the sites, not all surface water and soil/sediment samples were analyzed for metals. As a result, the metals analyses introduce uncertainty into the risk estimates and this is discussed in Section 3.5, Uncertainty Analysis.

No avian toxicity values were available for naphthalene, which was detected in one soil sample (i.e., S01 at the Fuel Storage Area). As a result, no HQs are calculated for naphthalene. This introduces additional uncertainty to the risk estimates; however, naphthalene is a constituent of DRPH, which was found to pose no risk to avian representative species.

4-Methylphenol was detected in one sediment sample (SD01) at the Old Landfill/Dump East Site. Avian toxicity values were not available for 4-methylphenol; therefore, HQ values were not calculated. 4-Methylphenol is considered relatively toxic in comparison to the other SVOCs detected at the Bullen Point installation; however, it is likely to volatilize and is not expected to present a significant risk to birds.

Based on the HQs presented in Table 3-24 and the above discussion, the risk to avian representative species at the Bullen Point installation is not estimated to be significant.

3.4.4 Potential Risks to Representative Species of Mammals

HQs for the brown lemming, arctic fox, and the barren-ground caribou were below 1.0 for all COCs. Based on these HQs, the risk to mammals at the Bullen Point installation is not significant. As noted in the risk characterizations for aquatic and avian species, the analyses for metals introduce uncertainty to the risk estimates. Another potential source of uncertainty is the lack of a quantitative analysis for potential mammalian exposure to 4-methylphenol. This chemical was detected in one sediment sample at the Old Landfill/Dump Site East. Toxicity values for 4-methylphenol are available for mammals, but the representative mammalian species are not likely to be exposed to sediments where 4-methylphenol was detected. The sample location is in a water body directly connected to a salt water lagoon and the mammals are not likely to use this location. Because the exposure pathways for the brown lemming, arctic fox, and caribou are unlikely to expose them to sediments at the landfill site, the risk from 4-methylphenol is qualitatively estimated to be low, and no quanititive analysis was performed. Refer to Section 3.5, Uncertainty Analysis, for a more detailed discussion of the uncertainties associated with limited detection (i.e., only one detection).

TABLE 3-24. HAZARD QUOTIENTS FOR REPRESENTATIVE BIRDS AND MAMMALS AT THE BULLEN POINT INSTALLATION

CHEMICAL OF CONCERN	ESTIMATED EXPOSURE mg/kg-bw/day	TRV mg/kg-bw/day	HAZARD QUOTIENT
IRON			
Lapland longspur	1×10^{-1}	55	2×10^{-3}
brant	5×10^{-3}	15	3×10^{-4}
glaucous gull	2×10^{-3}	14	1×10^{-4}
pectoral sandpiper	4×10^{-1}	38	1×10^{-2}
spectacled eider	4×10^{-2}	15	3×10^{-3}
brown lemming	2×10^{-1}	42	4×10^{-3}
arctic fox	3×10^{-3}	9.3	3×10^{-4}
caribou	2×10^{-3}	8.5	2×10^{-4}
DRPH			
Lapland longspur	5×10^{-1}	520	1×10^{-3}
brant	7×10^{-2}	140	5×10^{-4}
glaucous gull	2×10^{-2}	140	1×10^{-4}
pectoral sandpiper	1×10^{1}	360	3×10^{-2}
spectacled eider	4×10^{-1}	140	3×10^{-3}
brown lemming	9×10^{0}	310	3×10^{-2}
arctic fox	5×10^{-3}	69	8×10^{-5}
caribou	5×10^{-3}	26	2×10^{-4}
XYLENES (total)			
Lapland longspur	9×10^{-3}	26	3×10^{-4}
brant	1×10^{-3}	7.2	1×10^{-4}
glaucous gull	6×10^{-5}	6.8	8×10^{-6}
pectoral sandpiper	3×10^{-2}	18	1×10^{-3}
spectacled eider	2×10^{-3}	64	3×10^{-5}
brown lemming	3×10^{-1}	180	2×10^{-3}
arctic fox	1×10^{-5}	40	2×10^{-7}
caribou	2×10^{-4}	15	1×10^{-5}

NA Toxicity values were not available.
NC Not calculated because toxicity values were not available.

TABLE 3-24. HAZARD QUOTIENTS FOR REPRESENTATIVE BIRDS AND MAMMALS AT THE BULLEN POINT INSTALLATION (CONTINUED)

CHEMICAL OF CONCERN	ESTIMATED EXPOSURE mg/kg-bw/day	TRV mg/kg-bw/day	HAZARD QUOTIENT
NAPHTHALENE			
Lapland longspur	6×10^{-3}	NA	NC
brant	7×10^{-4}	NA	NC
glaucous gull	6×10^{-5}	NA	NC
pectoral sandpiper	3×10^{-2}	NA	NC
spectacled eider	2×10^{-3}	NA	NC
brown lemming	2×10^{-1}	42	4×10^{-3}
arctic fox	1×10^{-5}	9.3	1×10^{-6}
caribou	1×10^{-4}	3.5	3×10^{-5}
PCBs			
Lapland longspur	9×10^{-5}	116	8×10^{-7}
brant	1×10^{-5}	32	4×10^{-7}
glaucous gull	4×10^{-6}	31	1×10^{-7}
pectoral sandpiper	2×10^{-3}	80	3×10^{-5}
spectacled eider	1×10^{-4}	31	3×10^{-6}
brown lemming	1×10^{-3}	3	4×10^{-4}
arctic fox	1×10^{-6}	0.6	2×10^{-6}
caribou	5×10^{-7}	0.3	2×10^{-6}

NA Toxicity values were not available.
NC Not calculated because toxicity values were not available.

3.4.5 Potential Future Risks

Future risks at the POL Tanks (ST05), Old Landfill/Dump Site East (LF06), Fuel Storage Area (ST09), and Drum Storage Area (SS10) are expected to be as low as or lower than current risks because the exposure pathways are not likely to change, and the concentrations of COCs are likely to diminish over time. An exception to this future scenario is the Inside Transformer Site (OT04). Soil samples indicate the presence of low concentrations of PCBs under and adjacent to the structure on this site.

PCBs have very high chemical, thermal, and biological stability in addition to low vapor pressure (Manahan 1994). Conversion of highly substituted PCBs to molecules with one or two chlorines is done relatively slowly by anaerobic bacteria (Manahan 1994). Therefore, natural biodegradation may not be an effective process for reducing the PCB concentrations at the Inside Transformer site. In addition, PCBs have a high potential for bioaccumulation, which may result in exposure to PCBs by ecological receptors in the trophic web. Under current conditions, all PCB HQs are below 1.0 at the site. Given the low PCB concentrations in soil, and limited areas affected, the potential future risk is estimated to be low.

3.5 ECOLOGICAL RISK ASSESSMENT UNCERTAINTY ANALYSIS

As with any risk assessment, there is great uncertainty associated with the estimates of ecological risk for the sites at the Bullen Point installation. The risk estimates are based on a number of assumptions regarding exposure and toxicity. In general, the primary sources of uncertainty are the following:

Environmental Sampling and Analysis;
Selection of COCs;
Selection of Representative Species;
Exposure Parameter Estimation; and
Toxicological Data.

A complete understanding of the uncertainties associated with risk estimates is critical to placing the predicted risks in proper perspective. The most significant sources of uncertainty associated with the estimates of risk for the Bullen Point installation sites are summarized in the following sections.

3.5.1 Environmental Sampling and Analysis

The principal source of uncertainty in the analytical data (for the ERA) stems from the sampling approach and the subsequent calculation of exposure concentrations. Sampling at the Bullen Point installation was conducted in a systematic manner, designed to characterize localized contaminated areas or "hot spots". In order to compensate for this non-random sampling methodology in the calculation of exposure concentrations, the exposure assessment used the average concentration of COCs across the site.

The methods of calculating the average concentrations were the same for organic and inorganic data. In calculating the average concentration of chemicals at the site, non-detected chemicals were entered at one-half of the quantitation limit, as per EPA guidance (EPA 1989a). Sampling was designed to characterize "hot spots" at each of the sites. Therefore, the average concentrations of COCs tend to be biased high because sampling was generally concentrated in areas of the site where significant contamination exists or was suspected. In addition, the average concentrations of total metals used to estimate exposure in surface water may overestimate potential risk. The use of total metal concentrations in surface water to estimate risk is a conservative approach because dissolved metal concentrations generally are significantly less than total metal concentrations.

The limited analysis of metals is a factor that also contributes to uncertainty. Of the five surface water samples, only one was analyzed for metals, and the soil/sediment samples were analyzed for metals in only 5 of 57 instances. The selection of the inorganic COCs was based on these analyses and the resultant choices may under- or overestimate the true nature and extent of metals contamination at the Bullen Point installation. It is difficult to assess the degree of impact that this uncertainty has on the overall risk estimates, although the available data indicate that metals contamination is not likely to present risks at Bullen Point.

An additional factor related to the analysis of surface water samples should be considered. The sample quantitation limits of several metals were higher than the action levels used to screen the chemicals. For example, the sample quantitation limit of aluminum is <100 $\mu g/L$ and the action level is 87 $\mu g/L$. Therefore, non-detected concentrations of aluminum and other metals, including beryllium, cadmium, copper, chromium, lead, selenium, silver, and thallium, may be present in quantities sufficient to elicit adverse effects in aquatic organisms. This probably contributes a low level of uncertainty to the overall risk estimate because surface water pathways at the Bullen Point installation are not likely to be significant routes of exposure to representative species other than *Daphnia* spp.

Further, there is uncertainty inherent in using measurements of DRPH, GRPH, and RRPH for risk assessments. The analytical techniques are not specific to petroleum (i.e., they detect other organics, including naturally-occurring ones) (Von Burg 1993). Moreover, the toxicity of these groups of petroleum hydrocarbons is determined by the toxicity of their individual constituents. When petroleum compounds are released to the environment, they tend to weather or transform readily. For example, the lighter fractions (such as BTEX) will volatilize to the atmosphere more readily than the heavier fractions (such as decane, pyrene, or benzo(a)pyrene). The lighter fractions are thought to be the more toxic (Wong et al. 1981; O'Brien 1978; Kauss and Hutchinson 1975; Soto et al. 1975). Therefore, the toxicities of DRPH, GRPH, and RRPH are expected to change over time depending upon the attenuation mechanisms occurring in the environment. As a result, the toxicity of the petroleum hydrocarbons detected at the Bullen Point installation is unknown. Use of toxicity values reported in the literature probably contributes to an overestimation of the risk because it is likely that the most toxic components of the mixtures detected have volatilized to the atmosphere over time.

3.5.2 Selection of Chemicals for Evaluation

The selection of COCs in the ERA was based upon a comparison to background concentrations and action levels, and an evaluation of the frequency of detection. For certain chemicals, no action level was available. As a result, action levels for related compounds were used. This introduces some uncertainty into the risk assessment as there is a chance that actual toxicity is different from the toxicity of the surrogate chemical. Overall, however, the process provided a conservative screen of COCs, and it is unlikely that any chemicals presenting an ecological risk were omitted.

3.5.3 Selection of Representative Species

The selection of representative species in the ERA also introduces some uncertainty into the risk estimates. No site-specific biological surveys were conducted at the Bullen Point facility, with the exception of a survey for spectacled and Steller's eiders (Alaska Biological Research 1994). As a result, it is not known whether or how often the representative species are actually found at the site. However, the uncertainty introduced into the risk estimate by this route is low. The purpose of ERAs is not to survey the biota at a site, but to estimate the risks to species which may inhabit the area. Surrogate species are commonly used, even if the representative species do not reside at the Bullen Point installation. As a result, the risk estimates in this report will provide a sound measure of the potential risks to the species that do inhabit the area.

3.5.4 Exposure Assessment

Exposures were estimated from literature-based life history information for the selected representative species. There is moderate uncertainty associated with the exposure information. Food and water ingestion rates were not available for some animals and were estimated using regression equations. Incidental ingestion of soils and sediments may occur while animals are foraging in these media, and it is uncertain how much soil/sediment is actually ingested. In addition, there is uncertainty associated with the habitat at the site. Samples were collected around buildings and other structures that are likely to provide habitat of limited quality. As a result, this tends to overestimate exposure. Further, there are significant uncertainties associated with the estimates of how extensively a receptor will use the site, which were based on home range information. As noted in the discussion of Estimation of Percent Ingested Onsite, Section 3.2.7.2, the conversion of population density values as substitutes for home ranges adds uncertainty to the risk assessment. The conversion was necessary because home range data are lacking for some of the representative species.

There is some uncertainty associated with the diet compositions estimated from information obtained from the literature. A good example of this type of uncertainty is the unpredictable fluctuation in the populations of the brown lemmings and their predators (i.e., arctic fox, glaucous gull). As the numbers of prey increase, predator populations may experience numerical and density increases well beyond the values reported in the literature. When prey populations decrease, predation pressure can shift to diet items that are not considered "normal", and do not represent dietary intakes reported in the literature. Wildlife, and their interactions with the environment, are dynamic. Stochastic events, natural or anthropogenic, may cause behavior

and/or habits to differ markedly from the "expected or norm". Deviations from typical behavior cause uncertainty when evaluating wildlife and ecosystems.

There is also uncertainty associated with exposure estimates for plants. Plant uptake of COCs was derived from a regression equation using the K_{ow} of the COC (Table 3-5). This calculation estimates the concentration of chemicals in the vegetative portion of plants. Actual concentrations of the COC in plant tissue will vary depending upon actual chemical uptake, species of plant, and other site-specific factors (such as soil organic carbon). It is important to note that screening level tissue concentrations in plants were not available for comparison with these estimated concentrations. As a result, it is uncertain whether the concentrations are phytotoxic. However, the overall effect of this source of uncertainty in the risk assessment is low as is the ecological risk to plants.

In addition, the only component in the diet of representative species evaluated quantitatively was the ingestion of plants. Ingestion of animal prey (e.g., the diet of the arctic fox and the insectivorous portion of some avian diet) was not quantified. This may slightly underestimate risk for species that rely on animal items in their diet.

3.5.5 Toxicological Data

One of the largest sources of uncertainty in risk assessment is from the toxicological data. Often there are no relevant studies for the specific representative species or endpoints. As a result, extrapolations are made, which introduce uncertainty into the risk estimate. These extrapolations incorporate uncertainty factors into the calculation of TRVs. The purpose of the uncertainty factors is to incorporate some margin of error into the risk estimate, in order to arrive at a "safe" level of exposure to which onsite exposure concentrations may be compared. These techniques introduce into the risk assessment a tendency to overestimate rather than underestimate the risk.

For some chemicals, no toxicity information was available (e.g., naphthalene for birds). As a result, these compounds were not evaluated quantitatively in the risk assessment, and the risk estimates may be somewhat underestimated. However, based on the low concentrations and low frequency of detection of these compounds (as discussed in Section 3.1), the uncertainty associated with this factor is low.

Toxicity values for plants, water, soils, and sediments are based on literature values. Toxicity in soils and sediments is affected by the bioavailability of a given chemical. Toxicity of metals in water is based, in part, upon the speciation of the element. As a result, site-specific bioavailability or toxicity may differ from that in the studies used to estimate potential toxic effects. Therefore, actual toxicities of chemicals at the Bullen Point installation may be different from the values reported in the literature. In addition, the sensitivity of receptors on site may be different from the sensitivity of the species reported in the literature. This contributes to the overall uncertainty of the risk assessment.

There is a great deal of uncertainty in assessing the toxicity of a mixture of chemicals. In this ERA, the effects of exposure from each contaminant have been considered separately. However, these substances occur together at the site, and organisms may be exposed to mixtures of the

chemicals. Prediction of how these mixtures of toxicants will interact must be based on an understanding of the mechanisms of such interactions. The interactions of the individual components of chemical mixtures may occur during absorption, distribution, metabolism, excretion, or activity at the receptor site. Individual compounds may interact chemically, yielding a new toxic component or causing a change in the biological availability of an existing component, or may interact by causing different effects at different receptor sites. Suitable data are not currently available to rigorously characterize the effects of chemical mixtures, so chemicals present at the site were evaluated independently. This approach of assessing risk associated with mixtures of chemicals does not account for any additive, synergistic, or antagonistic interactions among the chemicals considered. However, as discussed in Section 3.6, the risk assessment yielded a low potential for ecological risks, and it is unlikely that additive effects of chemicals are a concern.

3.6 SUMMARY OF ECOLOGICAL RISK

The potential risks to ecological receptors are summarized in this section based on the information presented in Sections 3.1 through 3.4. The reader is referred to these sections for more details on the assessment. Conclusions regarding potential risks must be viewed in the context of the uncertainties associated with the assessment (Section 3.5) and the available risk information. The available risk information includes chemical data, exposure estimates, and literature-based toxicity information.

Table 3-25 presents a summary of the ecological risks at the Bullen Point installation. The table includes the potential risk to each ecological group evaluated, the COC that contributed to the potential risk, and the site(s) where the COCs were detected at relatively high concentrations.

TABLE 3-25. SUMMARY OF POTENTIAL ECOLOGICAL RISKS

ECOLOGICAL GROUP	POTENTIAL RISK	COC	SITES
Plants	Not Significant	DRPH (including constituent VOCs and SVOCs) in soil/sediment	POL Tanks (ST05), Fuel Storage Area (ST09)
Aquatic Organisms	Not Significant	iron in surface water	Old Landfill/Dump Site East (LF06)
Birds	Not Significant (Future PCB Risk: Low)	DRPH (including constituent VOCs and SVOCs) in soil/sediment; PCBs for future risk	POL Tanks (ST05), Fuel Storage Area (ST09); (Inside Transformer Site [OT04] for future risk)
Mammals	Not Significant (Future PCB Risk: Low)	DRPH (including constituent VOCs and SVOCs) in soil/sediment; PCBs for future risk	POL Tanks (ST05), Fuel Storage Area (ST09); (Inside Transformer Site [OT04] for future risk)

3.6.1 Potential Risks to Representative Plants

A qualitative comparison was conducted of onsite soil and surface water concentrations with plant toxicity information. The risk to plants is characterized using comparative information from the literature and BCF (B_v). Based on the qualitative comparison, the risks to plants is not significant.

3.6.2 Potential Risks to Representative Aquatic Species

Potential risks to aquatic species were evaluated by comparing toxicity information from the literature with the average exposure concentrations of potential contaminants in surface water. HQs for aquatic organisms indicate that risks may exist from iron. The HQ for iron for aquatic organisms is 2.9. However it is important to qualify this risk in terms of site specific conditions. The iron concentration was elevated above background concentrations by a small margin (2,900 μg/L in the surface water sample versus 2,800 μg/L for the maximum background iron concentration) in only one sample. It should be emphasized that one sample may not be sufficient to characterize potential metal contamination. The elevated concentration of iron that was detected came from a water body that freezes solid in the winter. This area is not suitable habitat for fish, but may provide habitat for invertebrates. In addition, the potential risk to aquatic species was based on total metal concentrations. If dissolved metal concentrations were used in the risk evaluation the risks are significantly less than noted above. Therefore, considering site-specific factors, the overall risk to aquatic organisms at the Bullen Point installation is not considered significant.

3.6.3 Potential Risks to Representative Species of Birds and Mammals

The risks to representative species of birds and mammals were evaluated using the quotient method. This method compares the estimated exposure with TRVs. The resulting HQs indicate that the overall risks to birds and mammals are not significant. None of the HQs exceeded 1 for any of the avian, mammalian, or protected terrestrial species. There may be a future potential for risk as a result of bioaccumulation of PCBs at the Inside Transformer Site, although the evaluation of current conditions indicates non-significant risks for birds and mammals.

The objective of this ERA is to evaluate the potential risk to the representative plant, aquatic and terrestrial species at the Bullen Point DEW Line installation. This assessment indicates that, overall, the potential risks presented by the COCs are not significant.

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APPENDIX A

RISK CHARACTERIZATION SPREADSHEETS

TABLE A-1. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
Endpoint: Noncancer
Assumptions: Site-specific
Installation: Bullen Point
Site: Inside Transformer (OT04)
File: OT04SONC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	14	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(ED x 365 days/year)	3,650	17,885	2,190

Chemical	Oral RfD	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/kg-day)			Hazard Quotients	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
Aroclor 1254	0.00002	0.9	2.47e-08	1.06e-07	9.86e-07	1.23e-03	5.46e-02
					HAZARD INDEX	0.001	0.055

TABLE A-2. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route:	Soil Ingestion
Endpoint:	Cancer
Assumptions:	Site-specific
Installation:	Bullen Point
Site:	Inside Transformer (OT04)
File:	OT04SOCA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	14	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(lifetime in days)	25,550	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Soil (mg/kg)	LADD by Receptor Group (mg/kg-day)			Cancer Risk	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
PCBs (Aroclor 1254)	7.7	0.9	3.52e-09	7.40e-08	8.45e-08	2.71e-08	1.22e-06
					CANCER RISK	3e-08	1e-06

TABLE A-3. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
Endpoint: Noncancer
Assumptions: Site-specific
Installation: Bullen Point
Site: POL Tanks (ST05)
File: ST05SONC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	14	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(ED x 365 days/year)	3,650	17,885	2,190

Chemical	Oral RfD	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/kg-day)			Hazard Quotients	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
DRPH	0.08	5860	1.61e-04	6.88e-04	6.42e-03	2.01e-03	8.89e-02
GRPH	0.2	170	4.66e-06	2.00e-05	1.86e-04	2.33e-05	1.03e-03
					HAZARD INDEX	0.002	0.090

TABLE A-4. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
Endpoint: Cancer
Assumptions: Site-specific
Installation: Bullen Point
Site: POL Tanks (ST05)
File: ST05SOCA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	14	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(lifetime in days)	25,550	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Soil (mg/kg)	LADD by Receptor Group (mg/kg-day)			Cancer Risk	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
GRPH	0.0017	170	6.65e-07	1.40e-05	1.60e-05	1.13e-09	5.09e-08
					CANCER RISK	1e-09	5e-08

TABLE A-5. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Water Ingestion
Endpoint: Noncancer
Assumptions: Site-specific
Installation: Bullen Point
Site: POL Tanks (ST05)
File: ST05WANC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	14	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(ED x 365 days/year)	3,650	20,075

Chemical	Oral RfD	Concentration Water (mg/L)	ADD by Receptor Group (mg/kg-day)		Hazard Quotient	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
DRPH	0.08	0.298	3.27e-04	4.20e-03	4.08e-03	5.25e-02
GRPH	0.2	0.723	7.92e-04	1.02e-02	3.96e-03	5.09e-02
				HAZARD INDEX	8.04e-03	1.03e-01

TABLE A-6. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route:	Water Ingestion
Endpoint:	Cancer
Assumptions:	Site-specific
Installation:	Bullen Point
Site:	POL Tanks (ST05)
File:	ST05WACA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	14	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(lifetime in days)	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Water (mg/L)	LADD by Receptor Group (mg/kg-day)		Cancer Risk	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
GRPH	0.0017	0.723	1.13e-04	8.00e-03	1.92e-07	1.36e-05
Benzene	0.029	0.002	3.13e-07	2.21e-05	9.08e-09	6.42e-07
				CANCER RISK	2e-07	1e-05

TABLE A-7. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Water Ingestion
Endpoint: Noncancer
Assumptions: Site-specific
Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)
File: LF06WANC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	14	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(ED x 365 days/year)	3,650	20,075

Chemical	Oral RfD	Concentration Water (mg/L)	ADD by Receptor Group (mg/kg-day)		Hazard Quotient	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
DRPH	0.08	1.87	2.05e-03	2.63e-02	2.56e-02	3.29e-01
				HAZARD INDEX	2.56e-02	3.29e-01

TABLE A-8. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
Endpoint: Noncancer
Assumptions: Site-specific
Installation: Bullen Point
Site: Fuel Storage Area (ST09)
File: ST09SONC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	14	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(ED x 365 days/year)	3,650	17,885	2,190

Chemical	Oral RfD	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/kg-day)			Hazard Quotients	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
DRPH	0.08	3830	1.05e-04	4.50e-04	4.20e-03	1.31e-03	5.81e-02
GRPH	0.2	406	1.11e-05	4.77e-05	4.45e-04	5.56e-05	2.46e-03
					HAZARD INDEX	0.001	0.061

TABLE A-9. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route:	Soil Ingestion
Endpoint:	Cancer
Assumptions:	Site-specific
Installation:	Bullen Point
Site:	Fuel Storage Area (ST09)
File:	ST09SOCA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	14	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(lifetime in days)	25,550	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Soil (mg/kg)	LADD by Receptor Group (mg/kg-day)			Cancer Risk	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
GRPH	0.0017	406	1.59e-06	3.34e-05	3.81e-05	2.70e-09	1.22e-07
					CANCER RISK	3e-09	1e-07

TABLE A-10. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Water Ingestion
Endpoint: Noncancer
Assumptions: Site-specific
Installation: Bullen Point
Site: Fuel Storage Area (ST09)
File: ST09WANC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	14	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(ED x 365 days/year)	3,650	20,075

Chemical	Oral RfD	Concentration Water (mg/L)	ADD by Receptor Group (mg/kg-day)		Hazard Quotient	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
DRPH	0.08	0.554	6.07e-04	7.81e-03	7.59e-03	9.76e-02
				HAZARD INDEX	7.59e-03	9.76e-02

TABLE A-11. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
Endpoint: Noncancer
Assumptions: Site-specific
Installation: Bullen Point
Site: Drum Storage Area (SS10)
File: SS10SONC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	14	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(ED x 365 days/year)	3,650	17,885	2,190

Chemical	Oral RfD	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/kg-day)			Hazard Quotients	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
DRPH	0.08	775	2.12e-05	9.10e-05	8.49e-04	2.65e-04	1.18e-02
					HAZARD INDEX	<0.001	0.012

APPENDIX B

TOXICITY PROFILES

TOXICOLOGY PROFILE FOR GASOLINE

GENERAL DATA

The chemical composition of gasoline is extremely variable, depending upon the crude oil starting material, types of processing and refining, blending and additives employed. Gasolines are formulated to meet fuel performance specifications, not to achieve a specific chemical composition. Volatility must be within a certain range to avoid vapor lock (too high) or sluggish acceleration (too low). In addition, the air-fuel mixture within the cylinder must burn uniformly to prevent "pinging" or "knocking." Often small quantities of butanes, pentanes, organo lead compounds or branched chain hydrocarbons are added to achieve uniform burning rates. McDermott and Killiany (1978) published a detailed gas chromatographic analysis of a premium grade gasoline listing 21 components that accounted for 92 percent of the gasoline vapors (Table 1). Low-volatility hydrocarbons (high carbon numbers) were not well represented.

Gasoline additives include organic lead (tetraethyl lead and tetramethyl lead) to a concentration of 0.1 g/gallon (7 ppm). Alkyl lead vapors have low volatility (vapor pressure = 0.4 mm Hg) compared to gasoline (400-775 mm Hg), so lead compounds should not be acutely hazardous by inhalation. To prevent accumulation of lead deposits, scavenging agents ethylene dichloride (EDC) and ethylene dibromide (EDB) are added to fuels, usually in a molar ratio EDC/EDB/Pb = 2:2:1.

FATE AND TRANSPORT

Gasoline released into the environment would be expected to evaporate rapidly because of its high vapor pressure (400-477 mm Hg). Studies of gasoline fate when added to **soils** show that the main clearance mechanism was evaporation, which can account for up to 75% removal from surface soils (Donaldson 1990). Microbial degradation plus evaporation can remove up to 90 percent of the added gasoline (Song 1988). Benzene, a volatile gasoline component of major toxicological interest, has a half life in the **air** of less than 1 day (Korte and Klein 1982). Gasoline has appreciable water solubility (12 to 16 percent) so it would be transported in ground **water** and may be found in well water.

TOXICITY DATA

Human Toxicological Profile

Like other solvents, gasoline has potent central nervous system (CNS) depressant activity. Breathing vapors at concentrations achieved during "huffing" or occupational overexposures has led to a variety of neurological symptoms: hallucinations, encephalopathy, ataxia, convulsions, Tourette's Disease, vertigo and nystagmus, and peripheral neuropathy (Von Burg 1989). Many of these symptoms may be attributed to n-hexane or alkyl lead compounds.

Ingestion of gasoline can occur during siphoning or abuse situations, or from contaminated well-water. Ingestion is accompanied by a burning sensation in the mouth, pharynx and chest. Swallowing large amounts of gasoline leads to coma and death by respiratory depression. A

TABLE 1. COMPOSITION OF A PREMIUM-GRADE GASOLINE

COMPOUND	VOL %
Propane	0.8
n-Butane	38.1
Isobutane	5.2
n-Pentane	7.0
Cyclopentane	0.7
2,3-DM-butane	0.7
2-M-pentane	2.1
3-M-pentane	1.6
n-Hexane	1.5
M-cyclopentane	1.3
2,4-DM-pentane	0.4
2,3-DM-pentane	0.7
2,2,4-TM-pentane	0.5
Isobutylene	1.1
2-M-1-butane	1.6
c-2-Pentene	1.2
2-M-2-butene	1.7
Benzene	0.7
Toluene	1.8
Xylene (m,p,o)	0.5
Total %	**92.1**

serious complication is the aspiration of hydrocarbons into the lung which produces a potentially lethal hemorrhagic pneumonitis (Lee and Seymour 1979).

Three epidemiologic studies showed no increased cancer risk in refinery workers (Hanis et al. 1982; Kaplan 1986; Wong 1987). In an epidemiological study of refinery workers and gasoline handlers, Thomas et al. (1982), found a significant increase in stomach and brain cancer with a trend to increased leukemia and cancer of the skin, prostate and pancreas.

Animal Toxicology and Significant Studies

The acute dermal LD_{50} of gasoline in rabbits is reported to be <5 ml/kg (Von Burg 1989). Liquid gasoline is considered a primary skin irritant because of the defatting and fissuring that occurs with repeated contact. Hypersensitivity response to gasoline can occur. Dermal absorption of gasoline is unlikely to result in systemic toxicity, but chronic exposure to alkyl lead additives may be toxic. Gasoline is acutely irritating to the eye, but animal studies indicate no effect lasting longer than seven days.

Exposure to concentrations of 1,000 - 5,000 ppm for 15-60 minutes can produce CNS depression. A 5-minute exposure to 20,000 ppm (20 percent) has been reported to be fatal (Von Burg 1989).

MacFarland (1982), reported a chronic inhalation study of gasoline in Fischer 344 rats and $B6C3F_1$ mice. Exposure levels were 0, 67, 292, and 2056 ppm for 6 hours/day, 5 days/week for 103 to 113 weeks. Male (but not female) rats exhibited a progressive renal tubular disease and renal carcinomas in all dose groups; renal effects in mice were not significantly different from controls. High dose female mice had an increased incidence of hepatocellular tumors(48 percent); the spontaneous incidence of these tumors is also high (14 percent). Males showed no increase (44 percent high dose vs. control 45 percent).

Reproductive Toxicity

Male rats exposed intermittently to about 650 ppm unleaded gasoline for 2 months showed endocrine changes which were attributed to stress. Pregnant females exposed to 0, 400, and 1,600 ppm unleaded gasoline on days 6-15 of gestation for 6 hrs/day did not show any teratogenic or fetotoxic effects. Mental retardation has been reported among offspring of gasoline-sniffing mothers.

Genotoxicity

Several common fuels gave negative results in the Ames <u>Salmonella typhimurium</u> assay, mouse lymphoma, and the rat bone marrow chromosomal aberration assay (Lebowitz et al. 1979). Unleaded gasoline did not induce unscheduled and replicative DNA synthesis in the male rat kidney at doses known to be nephrotoxic.

Carcinogenicity

As indicated earlier, chronic gasoline exposures produces renal tumors in rats.

REGULATIONS AND STANDARDS

The American Conference of Governmental Industrial Hygienists (ACGIH 1990) adopted a threshold limit value (TLV) of 300 ppm (mg/m^3) for gasoline vapors. Because of the complexity and variability in the composition of gasoline, OSHA has no standard; it regulates the toxic components by their respective PELs (e.g., n-hexane, benzene, alkyl lead).

Gasoline is not mentioned in HEAST (1990) as having a specific cancer slope factor (CSF) or reference dose (RfD). However, individual components such as benzene, aromatics, n-hexane have CSF or RfD values and should be evaluated individually.

COMPOUND CAS NO.	ACGIH TLV ppm	RfD (inhal) mg/kg/day	RfD (oral) mg/kg/day	SLOPE FACTOR (inhale) kg-day/mg	SLOPE FACTOR (oral) kg-day/mg
Benzene 71-43-2	0.1	N/A	N/A	2.9E-2	2.9E-2
Ethylene Dibromide 106-93-4	A2[a]	N/A	N/A	7.7E-1	8.5E+1
Ethylene Dichloride 107-06-2	10	N/A	N/A	9.1E-2	9.1E-2
n-Hexane 110-54-3	50	6E-1	2E-1	N/A	N/A
Tetraethyl Lead 78-00-2	0.1[b]	1E-7	2.9E-8	N/A	N/A

a A2 - Substance classed as a suspected human carcinogen, no ACGIH TLV listed.
b mg/m^3, not ppm.

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TOXICOLOGY PROFILE FOR DIESEL FUEL

GENERAL DATA

Petroleum fuels are classified into light, middle and heavy distillate fuels. Gasoline is a typical light distillate fuel and diesel fuel is considered to be a middle distillate material obtained from the distillation of crude oil. Included in this category of middle distillate fuels are jet fuel, kerosene and #2 fuel oils; many of the ecological and toxicological effects of these materials are very similar.

The chemical composition of diesel fuel is extremely variable and depends upon the crude oil source, types of processing and refining, blending and additives employed. These fuels are formulated to meet physical characteristics and not a specific chemical composition. Viscosity and volatility are the principal determinants of the fuel specifications. Diesel #1 is primarily a kerosene type of fuel produced mainly from straight run middle distillates. Diesel #2 also contains straight run middle distillates but is blended with straight run kerosene, straight run gas oils, light vacuum distillate and light thermally and/or catalytically cracked streams (IARC 1989).

Like other petroleum derived fuels, diesel fuels consist of paraffins, olefins, cycloparaffins, isoparaffins and aromatics, as well as additives. Additives can include amyl nitrates and alcohols, n-hexyl nitrate and octyl nitrate at levels of 0.1 to 0.2 percent used as cetane number enhancers (Kirk-Othmer 1984). The total aromatic content of diesel fuel is variable, but levels between 23 and 38 percent have been reported. The average total aromatic contact is probably in the range of 25 percent. The concentrations of the principal aromatic species of toxicological significance are presented in Table 2.

TABLE 2. REPRESENTATIVE VALUES FOR TOXICOLOGICALLY SIGNIFICANT AROMATIC CONTENT FOR DIESEL FUEL #2

COMPONENT	APPROXIMATE CONCENTRATION
Benzene	<50 ppm with an average of 10 ppm
Ethylbenzene	300 ppm
Toluene	200 ppm (max)
Xylene (mixed)	2,400 ppm

(personal communication, Chevron Corp.)

The odor threshold of diesel fuel is approximately 0.8 ppm.

FATE AND TRANSPORT

Microbial degradation plus evaporation can remove up to 90 percent of the added diesel fuel to **soil**. Depending on the soil characteristics, the half-life of diesel fuel in soil ranges from one to eight weeks (Song 1988). Volatilization to the **air** occurs and diesel fuel can be detected by its odor in the air. However, a vapor pressure value could not be located in the literature. Diesel fuel will percolate through the soil and float on the ground **water**. When spilled onto surface water, diesel fuels can be toxic to fish, waterfowl and algae.

TOXICITY DATA

Human Toxicological Profile

Like other solvents, diesel fuel can be expected to have central nervous system (CNS) depressant activity. However, since this fuel is not as volatile as gasoline, breathing vapors at concentrations sufficient to achieve a level of intoxication is not likely at normal temperatures and pressures. An attempt to generate a kerosene (diesel) laden atmosphere resulted in an ambient concentration of only 14 ppm (Carpenter et al. 1976). However, under certain occupational settings like tank cleaning, it may be possible to generate mists or aerosols that can lead to symptoms of overexposure. As with kerosene, these symptoms may include headache, dizziness, weakness, confusion, drowsiness and possibly death (HSDB 1991).

Ingestion of diesel fuel can occur during siphoning, or abuse situations, or from contaminated well-water. Ingestion may be accompanied by a burning sensation in the mouth, pharynx and chest, gastrointestinal hypermotility and diarrhea (Gosselin et al. 1984), and possibly nausea and vomiting. A serious complication is the aspiration of hydrocarbons into the lung, which produces a potentially-lethal hemorrhagic pneumonitis (Lee and Seymour 1979).

There have been reports of acute renal failure in people following exposure to diesel fuel (Barrientos et al. 1977; Crisp et al. 1979). Kryzanovskij (1971) reports that workers cleaning diesel storage tanks have an increased general incidence of disease, and specifically cardiovascular disease and bronchitis, over control shipyard workers.

Animal Toxicology and Significant Studies

The acute oral and dermal LD_{50} of diesel fuel is in the range of 9 ml/kg body weight. Eye irritation properties were minimal, but the primary skin irritation score of a marketplace sample was 6.8 indicating that this material is a strong skin irritant (Beck et al. 1982) Chronic skin contact can be expected to produce defatting, fissuring and cracking. There are no readily available reports on hypersensitivity. Response to diesel fuels can be expected because products on either side of diesel fuels distillation range have been reported to produce hypersensitivity reactions (Beck et al. 1982). Dermal absorption of gasoline is unlikely to result in systemic toxicity, but chronic poisoning of the readily absorbable alkyl lead additives is possible.

Exposure of CD-1 mice to diesel vapor for eight hours per day on five consecutive days resulted in a decrement of performance on the roto-rod test, square box activity test and hot plate test.

However, the corneal reflex and inclined plane test were unaffected. General observations noted vasodilation, ataxia, poor grooming and, in some cases, tremor (Kainz and White 1982).

Exposure of rats to aerosolized diesel fuel at concentrations up to 6 mg/L produced direct toxic effects on the lungs but did not produce any neurotoxicity (Dalbey et al. 1987).

Reproductive Toxicity

Female rats were exposed 6 hours per day to air concentrations of 0, 100, and 400 ppm during days 6 through 15 of gestation. Neither jet fuel or No. 2 fuel oil produced any significant detrimental effects on the reproductive parameters of the experimental animals (Beliles and Mecler 1982). Neither Jet Fuel A nor diesel fuel at exposure levels of 400 ppm, 6 hrs per day, 5 day per week for 8 weeks reduced the fertility of CD-1 male mice (API 1980a, 1980b).

Genotoxicity

Kerosene, jet fuel and diesel fuel all tested negatively in the standard Ames bioassay. However, the "Modified Ames Assay" (Blackburn et al. 1988) on two straight run gas oils did demonstrate mutagenicity straight run gas oil can be considered similar to diesel oils). Diesel fuel was also negative in the mouse lymphoma assay but positive on the rat bone marrow cytogenetics assay when administered by intraperitoneal injection (Conaway et al. 1982). Heating oil No. 2 did produce a positive Ames test as well as positive results in two other short term bioassays (Rothman and Emmett 1988). Dominant lethal testing of Jet fuel A and diesel fuel was negative at 400 ppm to male CD-1 mice (API 1980a, 1980b).

Carcinogenicity

In a classical mouse skin-painting bioassay, all petroleum fractions derived from a crude oil source that boiled between 120 and 700° F showed a low level of tumorigenic activity (Lewis et al. 1982). Home heating oil also showed a low level of tumorigenicity in a more recent mouse skin-painting assay (Witschi et al. 1987).

In a case referent study, Seimiatycki et al. (1987), reported an increase of several specific cancers associated with exposures to different petroleum products. Leaded gasoline was associated with stomach cancer; aviation gasoline with kidney cancer; diesel fuel with non adenocarcinoma of the lung and prostate cancer; and mineral spirits with squamous cell lung cancer. However, not all parameters of concern were properly controlled, excluded or assessed, making conclusions from this study inappropriate.

IARC (1989) has classified diesel fuel as having limited evidence of carcinogenicity in animals. Light diesel fuels are not classifiable as to their carcinogenicity to humans (Group 3).

REGULATIONS AND STANDARDS

Neither the American Conference of Governmental Industrial Hygienists (ACGIH) nor OSHA have recommended or established permissible exposure standards (PELs) for diesel fuels. However,

NIOSH has recommended a 10 hour TWA of 100 mg/m^3 or 14 ppm for kerosene (NIOSH 1977). Because of the complexity and variability in composition, OSHA regulates the toxic components by their respective PELs (i.e., n-hexane, benzene, etc.).

Diesel fuels, as such, are not mentioned in HEAST 1990, nor identified for a specific cancer Potency Factor (CPF) or reference dose (RfD). However, individual components such as benzene, other aromatics and n-hexane that have CPF or RfD values should be evaluated individually.

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BENZENE

Benzene is readily absorbed following oral and inhalation exposure (EPA 1985). The toxic effects of benzene in humans and other animals following exposure by inhalation include central nervous system effects, hematological effects, and immune system depression. In humans, acute exposures to high concentrations of benzene vapors have been associated with dizziness, nausea, vomiting, headache, drowsiness, narcosis, coma, and death (NAS 1976). Chronic exposure (at least 20 years of worker exposure) to benzene vapors [1-100 ppm 8-hour time-weighted-average (TWA)] can produce reduced leukocyte, platelet, and red blood cell counts (EPA 1993). Benzene induced tumors of the zymbal gland, oral cavity, leukemia and lymphoma in rodents chronically exposed by gavage to doses in the range of 25-500 mg/kg/day (Huff et al. 1989; NTP 1986; Maltoni et al. 1989). Many studies have also described a causal relationship between exposure to benzene by inhalation (either alone or in combination with other chemicals) and leukemia in humans (IARC 1982; Rinsky et al. 1981; Ott et al. 1978; Wong et al. 1983).

Applying EPA's criteria for evaluating the overall evidence of carcinogenicity to humans, benzene is classified in Group A (Human Carcinogen) based on adequate evidence of carcinogenicity from epidemiological studies. EPA (1993) derived an oral cancer slope factor of 2.9×10^{-2} $(mg/kg/day)^{-1}$ and an inhalation unit risk of 8.3×10^{-6} $(ug/m^3)^{-1}$ for benzene. These values were based on several studies in which increased incidence of nonlymphocytic leukemia were observed in humans occupationally exposed to benzene, principally by inhalation (Rinsky et al. 1981; Ott et al. 1978; Wong et al. 1983). Equal weight was given to cumulative dose and weighted cumulative dose as well as to relative and absolute risk model forms (EPA 1993). EPA (1993) is currently reviewing both oral and inhalation RfDs for benzene, for which the status is pending.

The National Research Council's Committee on Toxicology has set a one-hour Emergency Exposure Guidance Level (EEGL), for benzene at 50 ppm (200 mg/m^3) (NRC 1986). Formerly known as EEL, the EEGL is defined as a ceiling limit for an unpredicted single exposure lasting one to 24 hours, which is expected to be rare in the lifetime of any person. It is designed to avoid substantial decrements in performance during emergencies and takes into account the statistical likelihood of a non-incapacitative, reversible effect in exposed populations (NRC 1986). A health criterion for acute inhalation exposure to benzene of 20 mg/m^3 can be derived from the EEGL by combining it with a safety factor of 10 to account for the healthy worker effect, which assumes employed persons are generally healthier than the general population.

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POLYCHLORINATED BIPHENYLS (PCBs)

PCBs are complex mixtures of chlorinated biphenyls. The commercial PCB mixtures that were manufactured in the United States were given the trade name of "Aroclor." Aroclors are distinguished by a four-digit number (for example, Aroclor 1260). The last two digits in the Aroclor 1200 series represent the average percentage by weight of chlorine in the product.

PCBs are readily and extensively absorbed through the gastrointestinal tract and somewhat less readily through the skin; PCBs are presumably readily absorbed from the lungs, but few data are available that experimentally define the extent of absorption after inhalation (EPA 1985). Studies have found oral efficiency on the order of 75 to >90 percent in rats, monkeys and ferrets (Albro and Fishbein 1972; Allen et al. 1974; Tanabe et al. 1981; Bleavens et al. 1984; Clevenger et al. 1989). PCBs distribute preferentially to adipose tissue and concentrate in human breast milk because of its high fat content (ATSDR 1991). Dermatitis and chloracne (a disfiguring and long-term skin disease) have been the most prominent and consistent findings in studies of occupational exposure to PCBs. Several studies examining liver function in exposed humans have reported disturbances in blood levels of liver enzymes. Reduced birth weights, slow weight gain, reduced gestational ages, and behavioral deficits in infants were reported in a study of women who had consumed PCB-contaminated fish from Lake Michigan (EPA 1985). Reproductive, hepatic, immunotoxic, and immunosuppressive effects appear to be the most sensitive end points of PCB toxicity in nonrodent species, and the liver appears to be the most sensitive target organ in rodents (EPA 1985). For example, adult monkeys exposed to dietary concentrations of 0.028 mg/kg-day Aroclor 1016 for approximately 22 months showed no evidence of overt toxicity; however, the offspring of these monkeys exhibited decreased birth weight and possible neurological impairment (Barsotti and Van Miller 1984; Levin et al. 1988; Schantz et al. 1989, 1991). A number of studies have suggested that PCB mixtures are capable of increasing the frequency of tumors including liver tumors in animals exposed to the mixtures for long periods (Kimbrough et al. 1975; NCI 1978; Schaeffer et al. 1984; Norback and Weltman 1985). Studies have suggested that PCB mixtures can act to promote or inhibit the action of other carcinogens in rats and mice (EPA 1985). It is known that PCB congeners vary greatly in their potency in producing biological effects, such as cancer, however EPA (1995) generally considers Aroclor 1260 to be representative of all PCB mixtures for the evaluation of carcinogenic effects. There is some evidence that mixtures containing highly chlorinated biphenyls are more potent inducers of heptacellular carcinoma in rats than are mixtures containing less chlorine by weight (EPA 1995).

EPA (1995) classified PCBs as a Group B2 agent (Probable Human Carcinogen) based on sufficient evidence in animal bioassays and inadequate evidence from studies in humans. The EPA (1995) calculated an oral cancer potency factor of 7.7 $(mg/kg/day)^{-1}$ for PCBs based on the incidence of hepatocellular carcinomas (91 percent) and neoplastic nodules (4 percent) in female Sprague-Dawley rats exposed to a diet containing Aroclor 1260, as reported in a study by Norback and Weltman (1985). In the same study, males exhibited a much lower incidence of malignant tumors but a higher incidence of benign tumors (neoplastic nodules). EPA (1995) also calculated a slope factor of 5.7 $(mg/kg\text{-}day)^{-1}$ for malignant tumors alone, which is supported by a risk estimate based on the data of Kimbrough et al. (1975). EPA (1995) derived an oral RfD of 7×10^{-5} mg/kg/day for Aroclor 1016 based on a 21.8 month oral study conducted in monkeys

(Barsotti and Van Miller 1984; Levin et al. 1988; Schantz et al. 1989, 1991). A no-observed-adverse-effect level of 0.25 ppm (0.007 mg/kg/day) for decreased birth weight in offspring was identified from these studies. A safety factor of 100 (3 to account for interspecies extrapolation, 3 to account for sensitive individuals, 3 to account for limitations in the database, and 3 to account for extrapolation from a subchronic to a chronic RfD) was used to calculate the RfD.

EPA (1995) derived an oral RfD of 2×10^{-5} mg/kg/day for Aroclor 1254 based on clinical and immunological studies conducted in monkeys that received oral doses in gelatin capsules for more than five years (Arnold et al. 1994a,b; Tryphonas et al. 1989, 1991a,b; cited in EPA 1995). The critical effects observed in monkeys included ocular exudate, inflamed and prominent Meibomian glands, distorted growth of finger and toe nails, and a decreased antibody (IgG and IgM) response to sheep erythrocytes. To derive the oral RfD, an uncertainty factor of 300 was applied to the LOAEL from the cited studies. The uncertainty factor accounts for the variability in toxic responses among human individuals, for the extrapolation of a study in monkeys to potential exposures of humans, and for the use of a LOAEL instead of a NOAEL.

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APPENDIX C

BIOCONCENTRATION FACTOR CALCULATIONS

BIOCONCENTRATION FACTOR CALCULATIONS for ORGANIC CHEMICALS

CALCULATION OF Bv FOR ORGANIC CHEMICALS IN SOIL				
COC Organics	log Kow	1.588 - 0.578 log Kow	log Bv	Bv
DRPH	5.30	-1.475	-1.475	0.033
Xylenes (total)*	2.77	-0.013	-0.013	0.970
Naphthalene	3.36	-0.354	-0.354	0.443
PCBs	6.94	-2.423	-2.423	0.004

* log Kow for ortho-xylene used

APPENDIX D

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS

CF = CS*Bv*%V

INSTALLATION Bullen Point / SPECIES brown lemming / COC	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
Inorganics				
Iron	0	0.004	1.00	0.000
Organics				
DRPH	370	0.033	1.00	12.382
Xylenes (total)	0.67	0.970	1.00	0.650
Naphthalene	0.89	0.443	1.00	0.394
PCBs	0.09	0.004	1.00	0.000

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS
CF = CS*Bv*%V

INSTALLATION Bullen Point / SPECIES caribou / COC	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
Inorganics				
Iron	0.00	0.004	1.00	0.000
Organics				
DRPH	370.00	0.033	1.00	12.382
Xylenes (total)	0.67	0.970	1.00	0.650
Naphthalene	0.89	0.443	1.00	0.394
PCBs	0.09	0.004	1.00	0.000

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS

CF = CS*Bv*%V

INSTALLATION Bullen Point / SPECIES Lapland longspur / COC	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
Inorganics				
Iron	0.00	0.004	0.25	0.000
Organics				
DRPH	370.00	0.033	0.25	3.096
Xylenes (total)	0.67	0.970	0.25	0.163
Naphthalene	0.89	0.443	0.25	0.098
PCBs	0.09	0.004	0.25	0.000

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS

CF = CS*Bv*%V

INSTALLATION Bullen Point / SPECIES glaucous gull / COC	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
Inorganics				
Iron	0.00	0.004	0.10	0.000
Organics				
DRPH	370.00	0.033	0.10	1.238
Xylenes (total)	0.67	0.970	0.10	0.065
Naphthalene	0.89	0.443	0.10	0.039
PCBs	0.09	0.004	0.10	0.000

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS CF = CS*Bv*%V				
INSTALLATION Bullen Point SPECIES brant COC	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
Inorganics				
Iron	0.00	0.004	0.90	0.000
Organics				
DRPH	370.00	0.033	0.90	11.144
Xylenes (total)	0.67	0.970	0.90	0.585
Naphthalene	0.89	0.443	0.90	0.354
PCBs	0.09	0.004	0.90	0.000

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS
CF = CS*Bv*%V

INSTALLATION Bullen Point SPECIES pectoral sandpiper COC	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
Inorganics				
Iron	0.00	0.004	0.10	0.000
Organics				
DRPH	370.00	0.033	0.10	1.238
Xylenes (total)	0.67	0.970	0.10	0.065
Naphthalene	0.89	0.443	0.10	0.039
PCBs	0.09	0.004	0.10	0.000

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS
CF = CS*Bv*%V

INSTALLATION Bullen Point / SPECIES spectacled eider / COC	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
Inorganics				
Iron	0.00	0.004	0.25	0.000
Organics				
DRPH	370.00	0.033	0.25	3.096
Xylenes (total)	0.67	0.970	0.25	0.163
Naphthalene	0.89	0.443	0.25	0.098
PCBs	0.09	0.004	0.25	0.000

APPENDIX E

ESTIMATED EXPOSURE EQUATIONS

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point / SPECIES arctic fox / COC	COC Conc. Food Items (CF) (mg/kg)	Food Intake Rate (FI) (g/day)	(CF*FI) (A)	Soil/Sed. Intake % (SI%) % of FI	Soil/Sed. Ingestion Rate (SI) (g/day)	COC Conc. Soil /Sed. (CS) (mg/kg)	Relative Oral Availability (ROA) (unitless)	(SI*CS*ROA) (B)	COC Conc. Water (CW) (ug/L)	Water Intake Rate (WI) (L/day)	(CW*WI) (C)	(A+B+C) (D)	Conver. Units 0.0010 (D)*.001	Percent Ingested at Site (IS) (unitless)	Body Weight (BW) (kg)	ESTIMATED EXPOSURE (D*IS/BW=EE) (mg/kg-bw/day)
Inorganics																
Iron		256	0	0.028	7.168	0	1	0.0000	2900	0.42	1218	1218.00	1.2180	0.01	4.95	0.002
Organics																
DRPH		256	0	0.028	7.168	370	1	2652.1600		0.42	0	2652.16	2.6522	0.01	4.95	0.005
Xylenes (total)		256	0	0.028	7.168	0.67	1	4.8026		0.42	0	4.8026	0.0048	0.01	4.95	0.000
Naphthalene		256	0	0.028	7.168	0.89	1	6.3795		0.42	0	6.3795	0.0064	0.01	4.95	0.000
PCBs		256	0	0.028	7.168	0.09	1	0.6451		0.42	0	0.6451	0.0006	0.01	4.95	0.000

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point / SPECIES brown lemming	COC Conc. Food Items (CF)	Food Intake Rate (FI)	(CF*FI)	Soil/Sed. Intake % (SI%)	COC Conc. Soil /Sed. (CS)	Soil/Sed. Ingestion Rate (SI)	Relative Oral Availability (ROA)	(CS*SI*ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI)	(A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW=EE)
COC	(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(C)	(D)	(D)*.001	(unitless)	(kg)	(mg/kg-bw/day)
Inorganics																
Iron	0.0000	45	0.0000	0.027	0	1.215	1	0.0000	2900	0.007	20.3	20.30	0.0203	0.5	0.055	0.185
Organics						0										
DRPH	12.3823	45	557.2040	0.027	370	1.215	1	449.5500		0.007	0	1006.75	1.0068	0.5	0.055	9.152
Xylenes (total)	0.6502	45	29.2568	0.027	0.67	1.215	1	0.8141		0.007	0	30.0709	0.0301	0.5	0.055	0.273
Naphthalene	0.3938	45	17.7224	0.027	0.89	1.215	1	1.0814		0.007	0	18.8037	0.0188	0.5	0.055	0.171
PCBs	0.0003	45	0.0153	0.027	0.09	1.215	1	0.1094		0.007	0	0.1246	0.0001	0.5	0.055	0.001

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point SPECIES caribou	COC Conc. Food Items (CF)	Food Intake Rate (FI)	(CF*FI)	Soil/Sed. Intake % (SI%)	COC Conc. Soil /Sed. (CS)	Soil/Sed. Ingestion Rate (SI)	Relative Oral Availability (ROA)	(CS*SI*ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI)	(A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW=EE)
COC	(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(C)	(D)	(D)*.001	(unitless)	(kg)	(mg/kg-bw/day)
Inorganics																
Iron	0.0000	2400	0.000	0.02	0	48	1	0	2900	6.0	17400	17400.00	17.4000	0.01	95.5	0.002
Organics																
DRPH	12.3823	2400	29717.548	0.02	370	48	1	17760		6.0	0	47477.55	47.4775	0.01	95.5	0.005
Xylenes (total)	0.6502	2400	1560.364	0.02	0.67	48	1	32.16		6.0	0	1592.5244	1.5925	0.01	95.5	0.000
Naphthalene	0.3938	2400	945.195	0.02	0.89	48	1	42.72		6.0	0	987.9146	0.9879	0.01	95.5	0.000
PCBs	0.0003	2400	0.815	0.02	0.09	48	1	4.32		6.0	0	5.1350	0.0051	0.01	95.5	0.000

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point / SPECIES Lapland longspur	COC Conc. Food Items (CF)	Food Intake Rate (FI)	(CF*FI)	Soil/Sed. Intake % (SI%)	COC Conc. Soil /Sed. (CS)	Soil/Sed. Ingestion Rate (SI)	Relative Oral Availability (ROA)	(CS*SI*ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI)	(A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW=EE)
COC	(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(C)	(D)	(D)*.001	(unitless)	(kg)	(mg/kg-bw/day)
Inorganics																
Iron	0.0000	6.6	0.0000	0.02	0	0.132	1	0.0000	2900	0.005	14.5	14.50	0.0145	0.2	0.027	0.107
Organics																
DRPH	3.0956	6.6	20.4308	0.02	370	0.132	1	48.8400		0.005	0	69.27	0.0693	0.2	0.027	0.513
Xylenes (total)	0.1625	6.6	1.0728	0.02	0.67	0.132	1	0.0884		0.005	0	1.1612	0.0012	0.2	0.027	0.009
Naphthalene	0.0985	6.6	0.6498	0.02	0.89	0.132	1	0.1175		0.005	0	0.7673	0.0008	0.2	0.027	0.006
PCBs	0.0001	6.6	0.0006	0.02	0.09	0.132	1	0.0119		0.005	0	0.0124	0.0000	0.2	0.027	0.000

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point / SPECIES glaucous gull	COC Conc. Food Items (CF)	Food Intake Rate (FI)	(CF*FI)	Soil/Sed. Intake % (SI%)	COC Conc. Soil /Sed. (CS)	Soil/Sed. Ingestion Rate (SI)	Relative Oral Availability (ROA)	(CS*SI*ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI)	(A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW=EE)
COC	(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(C)	(D)	(D)*.001	(unitless)	(kg)	(mg/kg-bw/day)
Inorganics																
Iron	0.0000	73.9	0.0000	0.076	0	5.6164	1	0.0000	2900	0.08	232	232.00	0.2320	0.01	1.45	0.002
Organics																
DRPH	1.2382	73.9	91.5053	0.076	370	5.6164	1	2078.0680		0.08	0	2169.57	2.1696	0.01	1.45	0.015
Xylenes (total)	0.0650	73.9	4.8046	0.076	0.67	5.6164	1	3.7630		0.08	0	8.5676	0.0086	0.01	1.45	0.000
Naphthalene	0.0394	73.9	2.9104	0.076	0.89	5.6164	1	4.9986		0.08	0	7.9090	0.0079	0.01	1.45	0.000
PCBs	0.0000	73.9	0.0025	0.076	0.09	5.6164	1	0.5055		0.08	0	0.5080	0.0005	0.01	1.45	0.000

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point / SPECIES brant / COC	COC Conc. Food Items (CF) (mg/kg)	Food Intake Rate (FI) (g/day)	(CF*FI) (A)	Soil/Sed. Intake % (SI%) % of FI	COC Conc. Soil /Sed. (CS) (mg/kg)	Soil/Sed. Ingestion Rate (SI) (g/day)	Relative Oral Availability (ROA) (unitless)	(CS*SI*ROA) (B)	COC Conc. Water (CW) (ug/L)	Water Intake Rate (WI) (L/day)	(CW*WI) (C)	(A+B+C) (D)	Conver. Units 0.0010 (D)*.001	Percent Ingested at Site (IS) (unitless)	Body Weight (BW) (kg)	ESTIMATED EXPOSURE (D*IS/BW=EE) (mg/kg-bw/day)
Inorganics																
Iron	0.0000	69.2	0.0000	0.082	0	5.6744	1	0.0000	2900	0.07	203	203.00	0.2030	0.03	1.31	0.005
Organics																
DRPH	11.1441	69.2	771.1704	0.082	370	5.6744	1	2099.5280		0.07	0	2870.70	2.8707	0.03	1.31	0.066
Xylenes (total)	0.5851	69.2	40.4915	0.082	0.67	5.6744	1	3.8018		0.07	0	44.2933	0.0443	0.03	1.31	0.001
Naphthalene	0.3544	69.2	24.5278	0.082	0.89	5.6744	1	5.0502		0.07	0	29.5780	0.0296	0.03	1.31	0.001
PCBs	0.0003	69.2	0.0211	0.082	0.09	5.6744	1	0.5107		0.07	0	0.5318	0.0005	0.03	1.31	0.000

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point / SPECIES pectoral sandpiper	COC Conc. Food Items (CF)	Food Intake Rate (FI)	(CF*FI)	Soil/Sed. Intake % (SI%)	COC Conc. Soil /Sed. (CS)	Soil/Sed. Ingestion Rate (SI)	Relative Oral Availability (ROA)	(CS*SI*ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI)	(A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW=EE)
COC	(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(C)	(D)	(D)*.001	(unitless)	(kg)	(mg/kg-bw/day)
Inorganics																
Iron	0.0000	11.1	0.0000	0.181	0	2.0091	1	0.0000	2900	0.01	29	29.00	0.0290	1.0	0.08	0.363
Organics																
DRPH	1.2382	11.1	13.7444	0.181	370	2.0091	1	743.3670		0.01	0	757.11	0.7571	1.0	0.08	9.464
Xylenes (total)	0.0650	11.1	0.7217	0.181	0.67	2.0091	1	1.3461		0.01	0	2.0678	0.0021	1.0	0.08	0.026
Naphthalene	0.0394	11.1	0.4372	0.181	0.89	2.0091	1	1.7881		0.01	0	2.2253	0.0022	1.0	0.08	0.028
PCBs	0.0000	11.1	0.0004	0.181	0.09	2.0091	1	0.1808		0.01	0	0.1812	0.0002	1.0	0.08	0.002

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS

Estimated Exposure = ({[(CF*FI) + (CS*SI*ROA) + (CW*WI)] *.001}* IS) / BW

INSTALLATION Bullen Point / SPECIES spectacled eider	COC Conc. Food Items (CF)	Food Intake Rate (FI)	(CF*FI)	Soil/Sed. Intake % (SI%)	COC Conc. Soil /Sed. (CS)	Soil/Sed. Ingestion Rate (SI)	Relative Oral Availability (ROA)	(CS*SI*ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI)	(A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW=EE)
COC	(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(C)	(D)	(D)*.001	(unitless)	(kg)	(mg/kg-bw/day)
Inorganics																
Iron	0.0000	71.6	0.0000	0.082	0	5.8712	1	0.0000	2900	0.07	203	203.00	0.2030	0.25	1.375	0.037
Organics																
DRPH	1.2382	71.6	88.6574	0.082	370	5.8712	1	2172.3440		0.07	0	2261.00	2.2610	0.25	1.375	0.411
Xylenes (total)	0.0650	71.6	4.6551	0.082	0.67	5.8712	1	3.9337		0.07	0	8.5888	0.0086	0.25	1.375	0.002
Naphthalene	0.0394	71.6	2.8198	0.082	0.89	5.8712	1	5.2254		0.07	0	8.0452	0.0080	0.25	1.375	0.001
PCBs	0.0000	71.6	0.0024	0.082	0.09	5.8712	1	0.5284		0.07	0	0.5308	0.0005	0.25	1.375	0.000

APPENDIX F

SCALING FACTOR CALCULATIONS

SCALING FACTOR CALCULATIONS

Scaling factor (SF) = (representative species average body weight/ test species average body weight)$^{1/3}$ based on the mass to surface area ratios of the test species and the representative species (Mantel and Schneiderman 1975)

Representative Species	Average Body Weight[1] (kg)	Test Species	Average Body Weight[2] (kg)	Scaling Factor (SF)
brown lemming	0.055	mouse	0.025	1.30
	0.055	rat	0.25	0.60
arctic Fox	4.95	rat	0.25	2.70
	4.95	mouse	0.025	5.82
caribou	95.5	sheep	60	1.17
	95.5	cattle	500	0.58
	95.5	rat	0.25	7.24
	95.5	mouse	0.025	15.59
Lapland longspur	0.027	chicken	0.8	0.32
	0.027	mallard	1.08	0.29
	0.027	Japanese quail	0.10	0.65
	0.027	ringed dove	0.155	0.56
brant	1.305	chicken	0.8	1.18
	1.305	mallard	1.08	1.07
	1.305	Japanese quail	0.10	2.35
	1.305	ringed dove	0.155	2.03
glaucous gull	1.445	chicken	0.8	1.22
	1.445	mallard	1.08	1.10
	1.445	Japanese quail	0.10	2.43
	1.445	ringed dove	0.155	2.10
pectoral sandpiper	0.079	chicken	0.8	0.46
	0.079	mallard	1.08	0.42
	0.079	Japanese quail	0.10	0.92
	0.079	ringed dove	0.155	0.80
spectacled eider	1.375	chicken	0.8	1.20
	1.375	mallard	1.08	1.08
	1.375	Japanese quail	0.10	2.39
	1.375	ringed dove	0.155	2.07

APPENDIX G

RI ANALYTICAL DATA

(1)

TABLE G-1. SUMMARY OF SAMPLING AND ANALYSES CONDUCTED FOR

ANALYSES	VOC* 8010	BTEX*	VOC 8260	SVOC	Metals[b]	TPH-Diesel[b] Range 3510/3550	TPH - Gasoline[b] Range
ANALYTICAL METHOD	SW8010	SW8020	SW8260	SW8270	SW3050 (Soil) 3005 (Water)/6010	Diesel 8100M	Gas 5030/8015M
BULLEN POINT							
Background	5 Soil 2 Water	5 Soil 2 Water	5 Soil 2 Water	5 Soil 2 Water	5 Soil 2 Water (Total) 2 Water (Dissolved)	5 Soil 1 Water	5 Soil 2 Water
Inside Transformer (OT04)	NA	NA	NA	NA	NA	NA	NA
POL Tanks (ST05)	NA	24 Soil 4 Water	3 Soil 2 Water	3 Soil 2 Water	2 Soil	34 Soil 4 Water	24 Soil 4 Water
Old Landfill/Dump Site East (LF06)	9 Soil 2 Water	9 Soil 2 Water	2 Soil 1 Water	2 Soil 1 Water	2 Soil 1 Water (Total) 1 Water (Dissolved)	9 Soil 2 Water	9 Soil 2 Water
Fuel Storage Area (ST09)	NA	6 Soil 1 Water	1 Soil 1 Water	1 Soil 1 Water	NA	6 Soil 1 Water	6 Soil 1 Water
Drum Storage Area (SS10)	3 Soil	3 Soil	1 Soil	1 Soil	1 Soil	3 Soil	3 Soil
Total Field Analyses	17 Soil 4 Water	47 Soil 9 Water	12 Soil 6 Water	12 Soil 9 Water	10 Soil 3 Water (Total) 3 Water (Dissolved)	57 Soil 8 Water	47 Soil 9 Water
QA/QC SAMPLES							
Trip Blanks	1 Water[c]	3 Water	2 Water	NA	NA	NA	1 Water
Equipment Blanks	1 Water[c]	3 Water	2 Water	2 Water	2 Water (Total) 1 Water (Dissolved)	1 Water	3 Water
Ambient Condition Blanks	NA	NA	1 Water	NA	NA	NA	NA
Field Replicates	2 Soil	5 Soil	1 Soil	1 Soil	1 Soil	6 Soil	5 Soil
Field Duplicates	1 Water	1 Water	1 Water	1 Water	1 Water (Total) 1 Water (Dissolved)	1 Water	1 Water
Total Site Analyses	19 Soil 7 Water	52 Soil 16 Water	13 Soil 12 Water	13 Soil 12 Water	11 Soil 6 Water (Total) 5 Water (Dissolved)	63 Soil 10 Water	52 Soil 14 Water

NA Not analyzed.
* These analyses were completed on a quick turnaround basis.
a The number of soil sample includes sediment samples collected from surface water features.
b Some of these analysis were completed on a 24-hour turnaround at a temporary fixed laboratory at Barrow, Alaska.
c These samples were analyzed for a short list of four HVOCs using a modified method (SW8010M).
d Investigation derived wastes from Bullen Point were combined with the investigation derived wastes from Oliktok Point. These w

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S CONDUCTED FOR BULLEN POINT REMEDIAL INVESTIGATIONS[a]

iesel[b] ge 3550	TPH - Gasoline[b] Range	TPH Residual Range*	PCB*	Pesticides*	TDS	TSS	TOC	TCLP[d]	TOTAL SAMPLES
i100M	Gas 5030/8015M	Diesel 8100M	SW8080/8080M	SW8080/8080M	E160.1	E160.2	SW9060	SW1311	
oil ater	5 Soil 2 Water	NA	5 Soil 1 Water	5 Soil 1 Water	2 Water	2 Water	2 Water	NA	5 Soil 2 Water
\	NA	NA	5 Soil 3 Wipe	4 Soil	NA	NA	NA	NA	5 Soil 3 Wipe
oil ater	24 Soil 4 Water	10 Soil	2 Soil	2 Soil	2 Water	2 Water	2 Water	NA	34 Soil 4 Water
oil ater	9 Soil 2 Water	NA	9 Soil 2 Water	9 Soil 2 Water	1 Water	1 Water	1 Water	NA	9 Soil 2 Water
oil ater	6 Soil 1 Water	1 Soil	NA	NA	1 Water	1 Water	1 Water	NA	6 Soil 1 Water
oil	3 Soil	NA	3 Soil	NA	NA	NA	NA	NA	3 Soil
oil ater	47 Soil 9 Water	11 Soil	24 Soil 3 Water 3 Wipe	20 Soil 3 Water	6 Water	6 Water	6 Water	NA	62 Soil 9 Water 3 Wipe
\	1 Water	NA	NA	NA	NA	NA	NA	NA	3 Water
ater	3 Water	NA	1 Water	1 Water	NA	NA	NA	NA	3 Water
\	NA	NA	NA	NA	NA	NA	NA	NA	1 Water
oil	5 Soil	1 Soil	3 Soil	3 Soil	NA	NA	NA	NA	7 Soil
ater	1 Water	NA	1 Water	1 Water	1 Water	1 Water	1 Water	NA	1 Water
oil ater	52 Soil 14 Water	12 Soil	27 Soil 5 Water 3 Wipe	23 Soil 5 Water	7 Water	7 Water	7 Water	1 Water	69 Soil 17 Water 3 Wipe

row, Alaska.

m Oliktok Point. These were collectively sampled during the Oliktok Point investigation.

TABLE G-2. INSIDE TRANSFORMER ANALYTICAL DATA SUMMARY

Installation: Bullen Point
Site: Inside Transformer (OT04)
Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blank	Lab Blanks	
					S01	S02	S03	S04 & S05 (Replicates)		2S06-2	EB02		
Laboratory Sample ID Numbers					127	128	129	130	131	1862	4180-1 4180-2 4205-1	4180 4205	#5-81993 #5-9393
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	mg/kg
Pesticides	0.001-0.05	0.01-0.5		<0.002-<0.02	<0.01R-<0.5R	<0.01J-<0.5J	<0.01J-<0.5J	<0.01J-<0.5J	<0.01J-<0.5J	NA	<0.1-<2	<0.1-<1.0	<0.01J-<0.5J
PCBs													
Aroclor 1254	0.01	0.1	10	<0.2	<0.1R	0.9J	<0.1J	0.31J	0.63J	<0.1J	<2	<1	<0.1J

☐ CT&E Data.
▩ F&B Data.
NA Not analyzed.
J Result is an estimate.
R Result has been rejected.

AK-RISK\BULLEN\APP-G\4109661203\G-2.TBL

TABLE G-2. INSIDE TRANSFORMER ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Inside Transformer (OT04)
Matrix: Wipe
Units: $\mu g/100cm^2$

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples				Field Blank				Lab Blank
					WP01	WP02	WP03						
Laboratory Sample ID Numbers					Wipe Sample 4124-1	Wipe Sample 4124-2	Wipe Sample 4124-3						4124
ANALYSES	μg	μg	μg	μg	$\mu g/100\ cm^2$	$\mu g/100\ cm^2$	$\mu g/100\ cm^2$						$\mu g/L$
PCBs													
Aroclor 1254	1.0	1.0		NA	18.9	391.1	194						<0.01

☐ CT&E Data.
NA Not analyzed.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY

Installation: Bullen Point   Matrix: Soil
Site: POL Tanks (ST05)   Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples							Field Blanks			Lab Blanks	
					S01-1	S02-4 & S22-4 (Replicates		S03-0.6	S04-1.5	S05-2.5	S06-2.5	AB01	EB02	TB02		
Laboratory Sample ID Numbers					4200-1	4177-1 4200-4	4177-4 4200-28	4200-5	4200-8	4200-9	4177-2 4200-10	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4177 4200
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	841	2,250	1,940	1,180	1,960	2,440	5,860[d]	NA	<200	NA	<200	<4.00
GRPH	0.400	0.400	100	<0.500-1.03	17.0	114J	12.6J	170	42.7	137	20.1	NA	<20	NA	<20	<0.400
BTEX (8020/ 8020 Mod.)			10 Total BTEX	<0.125-<0.20	1.242	1.993	0.499J	5.801	1.045	2.725	3.333N					
Benzene	0.020	0.020-0.350	0.5	<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.025	<0.020	<0.350	<1[c]	<1	<1	<1	<0.020
Toluene	0.020	0.020-0.350		<0.025-<0.040	0.031	0.026	<0.020J	0.081	0.060	0.056	0.423N	<1[c]	<1	<1	<1	<0.020
Ethyl-benzene	0.020	0.020-0.350		<0.025-<0.040	0.261	0.356	0.096J	1.29	0.463	1.14	<0.350	<1[c]	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.040-0.700		<0.050-<0.080	0.950	1.611	0.403J	4.43	0.522	1.529	2.910N	<2[c]	<2	<2	<2	<0.040
VOC 8260																
n-Butyl-benzene	0.020	0.100		<0.025-<0.035	NA	<0.1J	<0.100	NA	NA	NA	0.174J	<1	<1	<1	<1	<0.020
p-Isopropyl-toluene	0.020	0.100		<0.025-<0.035	NA	<0.1J	<0.100	NA	NA	NA	0.112J	<1	<1	<1	<1	<0.020
Naphthalene	0.020	0.100		<0.025-<0.035	NA	<0.1J	<0.100	NA	NA	NA	0.902J	<1	<1	<1	<1	<0.020
1,2,4-Trimethyl-benzene	0.020	0.100		<0.025-<0.035	NA	0.837J	0.944	NA	NA	NA	0.672J	<1	<1	<1	<1	<0.020
1,3,5-Trimethyl-benzene	0.020	0.100		<0.025-<0.035	NA	5.04J	5.82	NA	NA	NA	0.262J	<1	<1	<1	<1	<0.020

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.
N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative indentification".
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c BTEX determined by 8260 method analysis.
d The laboratory reported that 1,200 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)
Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples							Field Blanks			Lab Blanks	
					S01-1	S02-4 & S22-4 (Replicates		S03-0.6	S04-1.5	S05-2.5	S06-2.5	AB01	EB02	TB02		
Laboratory Sample ID Numbers					4200-1	4177-1 4200-4	4177-4 4200-28	4200-5	4200-8	4200-9	4177-2 4200-10	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4177 4200
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
Xylenes (Total)	0.040	0.200		<0.050-<0.070	NA	0.791J	0.501[d]	NA	NA	NA	0.194J[c]	<2	<2	<2	<2	<0.040
SVOC 8270																
2-Methyl-naphthalene	0.200	0.210-0.640		<0.240-<1.00	NA	0.488	1.20	NA	NA	NA	0.946	NA	<11.2	NA	<10	<0.200
Naphthalene	0.200	0.210-0.640		<0.240-<1.00	NA	<0.210	<0.210	NA	NA	NA	0.457J	NA	<11.2	NA	<10	<0.200
Pesticides	0.001	0.002-0.020		<0.002-<0.020	NA	NA	NA	<0.003-<0.03	NA	NA	NA	NA	<0.1-<2	NA	<0.1-<1	<0.001-<0.020
PCBs	0.020	0.020-0.030	10	<0.020	NA	NA	NA	<0.030	NA	NA	NA	NA	<2	NA	<1	<0.020

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.
c This result is indicative of p&m xylenes.
d This result is indicative of o-xylene.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)
Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks	
					S07-1.5	S08-0.5	S09-3	S10-2	S11-1.5	S12-1.5	AB01	EB02	TB02		
Laboratory Sample ID Numbers					4200-11	4200-12	4200-13	4200-14	4200-15	4200-16	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4200
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	154[c]	27.9[c]	32.5[c]	27.6[c]	174[c]	708[d]	NA	<200	NA	<200	<4.00
GRPH	0.400	0.400-1.00	100	<0.500-1.03	<1.00	<0.600	<0.800	<0.600	<0.500	21.4	NA	<20	NA	<20	<0.400
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.125-<0.20	<0.300	<0.150	<0.200	<0.150	<0.125	3.065					
Benzene	0.020	0.025-0.060	0.5	<0.025-<0.040	<0.060	<0.030	<0.040	<0.030	<0.025	<0.035	NA	<1	<1	<1	<0.020
Toluene	0.020	0.025-0.060		<0.025-<0.040	<0.060	<0.030	<0.040	<0.030	<0.025	0.091	NA	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.025-0.060		<0.025-<0.040	<0.060	<0.030	<0.040	<0.030	<0.025	0.084	NA	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.050-0.120		<0.050-<0.080	<0.12	<0.060	<0.080	<0.060	<0.050	2.89	NA	<2	<2	<2	<0.040

☐ CT&E Data.
NA Not analyzed.
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.
d The laboratory reported that 155 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)
Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples							Field Blanks			Lab Blanks	
					S13-1.5	S14-2	S15-0.5	S16-2.5	S17-2	S18-2 & S23-2 (Replicates)		AB01	EB02	TB02		
Laboratory Sample ID Numbers					4177-3 4200-17	4200-18	4200-19	4200-20	4200-21	4200-22	4200-29	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4200 4177
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	225J[d]	33.0	67.3	4.05[d]	67.0	71.5[d]	364[d]	NA	<200	NA	<200	<4.00
GRPH	0.400	0.400-1.00	100	<0.500-1.03	10.7	14.1	0.701	<0.400	<0.400	2.82	<1.00	NA	<20	NA	<20	<0.400
BTEX (8020/ 8020 Mod.)			10 Total BTEX	<0.125-<0.20	0.497N	0.288	<0.100	0.056	<0.100	0.138	<0.275					
Benzene	0.020	0.020-0.055	0.5	<0.025-<0.040	0.031N	<0.020	<0.020	<0.020	<0.020	<0.020	<0.055	<1[c]	<1	<1	<1	<0.020
Toluene	0.020	0.020-0.055		<0.025-<0.040	0.040N	<0.020	<0.020	0.023	<0.020	<0.020	<0.055	<1[c]	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.020-0.055		<0.025-<0.040	0.069N	0.073	<0.020	<0.020	<0.020	0.033	<0.055	<1[c]	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.040-0.110		<0.050-<0.080	0.357N	0.215	<0.040	0.033[e]	<0.040	0.105	<0.110	<2[c]	<2	<2	<2	<0.040
VOC 8260																
Ethylbenzene	0.020	0.100		<0.025-<0.035	0.059J	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
Toluene	0.020	0.100		<0.025-<0.035	0.033J	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
1,2,4-Trimethyl-benzene	0.020	0.100		<0.025-<0.035	0.072J	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
1,3,5-Trimethyl-benzene	0.020	0.100		<0.025-<0.035	0.025J	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.200		<0.050-<0.070	0.299J	NA	NA	NA	NA	NA	NA	<2	<2	<2	<2	<0.020
SVOC 8270																
di-n-Butyl-phthalate	0.200	0.210-0.640	8,000	<0.240-<1.00	0.571	NA	NA	NA	NA	NA	NA	NA	<11.2	NA	<10	<0.200

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.
N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c BTEX determined by 8260 method analysis.
d The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.
e The result is indicative of p & m xylenes.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)
Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples							Field Blanks			Lab Blanks	
					S13-1.5	S14-2	S15-0.5	S16-2.5	S17-2	S18-2 & S23-2 (Replicates)		AB01	EB02	TB02		
Laboratory Sample ID Numbers					4177-3 4200-17	4200-18	4200-19	4200-20	4200-21	4200-22	4200-29	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4200 4177
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
bis (2-Ethyl-hexyl) phthalate	0.200	0.210-0.640	50	<0.240-<1.00	0.306	NA	NA	NA	NA	NA	NA	NA	<11.2	NA	<10	<0.200
Pesticides	0.001	0.002-0.020		<0.002-<0.020	<0.002-<0.020	NA	NA	NA	NA	NA	NA	NA	<0.1-<2	NA	<0.1-<1.0	<0.0010-<0.0200
PCBs	0.020	0.020-0.030	10	<0.020	<0.020	NA	NA	NA	NA	NA	NA	NA	<2	NA	<1.0	<0.020

☐ CT&E Data.
NA Not analyzed.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point   Matrix: Soil
Site: POL Tanks (ST05)   Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks	
					S19-1.5	S20-2	S21-1.5	S24	S25	S26	AB01	EB02	TB02		
Laboratory Sample ID Numbers					4200-23	4200-24	4200-25	4201-1	4201-2	4201-3	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4200
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	18.8	25.8[c]	57.2[c]	96.7[d]	21.7[e]	80.7[f]	NA	<200	NA	<200	<4.00
GRPH	0.400	0.400-1.00	100	<0.500-1.03	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	NA	<20	NA	<20	<0.400
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.125-<0.20	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100					
Benzene	0.020	0.020	0.5	<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	NA	<1	<1	<1	<0.020
Toluene	0.020	0.020		<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	NA	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.020		<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	NA	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.040		<0.050-<0.080	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	NA	<2	<2	<2	<0.040

☐ CT&E Data.
NA Not analyzed.
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.
d The laboratory reported that 11.4 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.
e The laboratory reported that 7.15 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.
f The laboratory reported that 76.8 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)
Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples							Field Blanks			Lab Blank
					2S27-1	2S28-1.75	2S29-2.5	2S30-2.5	2S31-2 & 2S36-2 (Replicates)		2S32-2	AB01	2EB03	2TB03	
Laboratory Sample ID Numbers					1850	1851	1852	1853	1854	1859	1868	4180-3	1864	1868	#6-9893
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	mg/kg
DRPH	5-6	50-60	500[a]	<4.00-157	<50[b]	<60[b]	220J[b]	2,400J[b]	3,400J[b]	3,000J[b]	310J[b]	NA	NA	NA	NA
RRPH	10-16	100-160	2,000[a]	NA	<100	<120	<160	<120	<120	<120	<120	NA	NA	NA	NA

- □ CT&E Data.
- ▩ F&B Data.
- NA Not analyzed.
- J Result is an estimate.
- a The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.
- b The DRPH concentrations reported for these samples are equivalent to diesel range organics (DRO) as defined by ADEC.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)

Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples							Field Blanks			Lab Blank
					2S33-1.5	2S34-2.5	2S35-2.5	2S37-1.33				AB01	2EB03	2TB03	
Laboratory Sample ID Numbers					1856	1857	1858	1868				4180-3	1864	1866	#6-9893
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg				μg/L	μg/L	μg/L	mg/kg
DRPH	6	60	500[a]	<4.00-157	<60[b]	3,300J[b]	1,600J[b]	<60[b]				NA	NA	NA	NA
RRPH	12	120	2,000[a]	NA	<120	<120	<120	<120				NA	NA	NA	NA

☐ CT&E Data.
▩ F&B Data.
NA Not analyzed.
J Result is an estimate.
a The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.
b DRPH concentrations reported for these samples are equivalent to diesel range organics (DRO) as defined by ADEC.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point Site: POL Tanks (ST05)		Matrix: Soil Units: mg/kg		METALS ANALYSES											
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples							Field Blank			Lab Blank
					S02-4& S22-4 (Replicates)		S13-1.5						EB02		
Laboratory Sample ID Numbers					4177-1	4177-4	4177-3						4180-1		4180 4711
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg						µg/L		µg/L
Aluminum	0.35	2		1,500-25,000	1,300	1,000	11,000						<100		<100
Antimony	N/A	52-58		<7.8-<230	<52	<52	<58						<100		<100
Arsenic	0.11	5.2-5.8		<4.9-<8.5	<5.2	<5.2	<5.8						<100		<100
Barium	0.024	1		27-390	17	14	130						<50		<50
Beryllium	N/A	1-2.6		<2.6-6.4	<2.6	<2.6	3.8						<50		<50
Cadmium	0.33	2.6-2.9		<3.0-<36	<2.6	<2.6	<2.9						<50		<50
Calcium	0.69	4		360-59,000	55,000J	19,000	5,800J						290		<200
Chromium	0.066	1-2.6		<4.3-47	2.8	<2.6	18						<50		<50
Cobalt	N/A	52-58		<5.1-12	<52	<52	<58						<100		<100
Copper	0.045	1-3.0		<2.7-45	3.7	<3.0	12						<50		<50
Iron	0.50	2		5,400-35,000	4,100	3,700	15,000						<100		<100
Lead	0.13	5.2-5.8		<5.1-22	<5.2	<5.2	<5.8						<100		<100
Magnesium	0.96	4		360-7,400	1,500J	1,600	3,000J						<200		<200
Manganese	0.025	1		25-290	56J	49	73J						<50		<50
Molybdenum	N/A	2.6-2.9		<2.5-<11	<2.6	<2.6	<2.9						<50		<50
Nickel	0.11	1		4.2-46	4.5	3.7	16						<50		<50

☐ CT&E Data.
N/A Not available.
J Result is an estimate.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point   Matrix: Soil   METALS ANALYSES
Site: POL Tanks (ST05)   Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples							Field Blank			Lab Blank
					S02-4& S22-4 (Replicates)		S13-1.5						EB02		
Laboratory Sample ID Numbers					4177-1	4177-4	4177-3						4180-1		4180 4711
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg						µg/L		µg/L
Potassium	23	100-260		<300-2,200	<260	<260	950						<5,000		<5,000
Selenium	1.2	52-58		<7.8-<170	<52	<52	<58						<100		<100
Silver	0.53	2.6-2.9		<3-<110	<2.6	<2.6	<2.9						<50		<50
Sodium	0.55	5		<160-680	32	30	220						540J		<250
Thallium	0.011	0.25-0.30		<0.2-<1.2	<0.25	<0.26	<0.30						<5		<5
Vanadium	0.036	1		6.3-59	4.0	3.3	28						<50		<50
Zinc	0.16	1		9.2-95	16	10	29						<50		<50

☐ CT&E Data.
N/A Not available.
J Result is an estimate.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)

Matrix: Surface / Ground Water
Units: µg/L

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples					Field Blanks			Lab Blanks
					SW01	SW02	GW01	GW02		AB01	EB02	TB02	
Laboratory Sample ID Numbers					4205-3	4205-4	4180-6 4205-2	4180-8 4205-6		4180-3	4180-2 4180-1 4205-1	4180-9 4205-7	4180 4205
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L
DRPH	100	200		<200	<200	298[ad]	423,000[a]	899[ad]		NA	<200	NA	<200
GRPH	20	20		<20	<20	<20	723[a]	53[a]		NA	<20	NA	<20
BTEX (8020/8020 Mod.)													
Benzene	1	1	5	<1	<1	<1	<1	1.8		<1[c]	<1	<1	<1
Toluene	1	1	1,000	<1	<1	<1	4N	<1		<1[c]	<1	<1	<1
Ethylbenzene	1	1	700	<1	<1	<1	13N	<1		<1[c]	<1	<1	<1
Xylenes (Total)	2	2	10,000	<2	<2	<2	34N	<2		<2[c]	<2	<2	<2
VOC 8260													
Benzene	1	1	5	<1	NA	NA	<1	2		<1	<1	<1	<1
1,2-Dichloroethane	1	1	5	1.9B-4.5B	NA	NA	<1	2.6		<1	<1	<1	<1
p-Isopropyltoluene	1	1		<1	NA	NA	15	<1		<1	<1	<1	<1
Naphthalene	1	1		<1	NA	NA	8.7	<1		<1	<1	<1	<1
Toluene	1	1	2,000	<1	NA	NA	1.4	<1		<1	<1	<1	<1
1,2,4-Trimethylbenzene	1	1		<1	NA	NA	35	<1		<1	<1	<1	<1
1,3,5-Trimethylbenzene	1	1		<1	NA	NA	62	<1		<1	<1	<1	<1

☐ CT&E Data.
NA Not analyzed.
B The analyte was detected in the associated blank.
N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".
a Total hydrocarbons in these water samples exceed the 15 µg/L stated for fresh water in ADEC's Water Quality Criteria 18AAC70 (ADEC 1989).
c BTEX determined by 8260 method analysis.
d The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-3. POL TANKS ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: POL Tanks (ST05)

Matrix: Surface / Ground Water
Units: µg/L

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples					Field Blanks			Lab Blanks
					SW01	SW02	GW01	GW02		AB01	EB02	TB02	
Laboratory Sample ID Numbers					4205-3	4205-4	4180-6 4205-2	4180-8 4205-6		4180-3	4180-2 4180-1 4205-1	4180-9 4205-7	4180 4205
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L
Xylenes (Total)	2	2	10,000	<2	NA	NA	10.7	<2		<2	<2	<2	<2
SVOC 8270													
2-Methylnaphthalene	10	10-1,000		<10	NA	NA	6,500J	<10		NA	<11.2	NA	<10
TOC	5,000	5,000		17,000-30,700	NA	NA	409,000	63,500		NA	NA	NA	<5,000
TSS	100	200		13,000-19,000	NA	NA	1,680,000	2,700,000		NA	NA	NA	<200
TDS	10,000	10,000		241,000-1,853,000	NA	NA	850,000	926,000		NA	NA	NA	<10,000

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.

TABLE G-4. OLD LANDFILL/DUMP SITE EAST ANALYTICAL DATA SUMMARY

Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)
Matrix: Soil
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples					Field Blanks			Lab Blanks	
					S01	S02	S03	S04	S05-0.6	AB01	EB01	TB01		
Laboratory Sample ID Numbers					4202-6	4123-8 4202-9	4202-10	4202-11	4202-12	4180-3	4204-9 4121-7 4122-7	4122-8 4204-8	4120/4122 4180/4204	4123 4202
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	34.9[d]	51.0[d]	<4.00	145	219[d]	NA	NA	NA	NA	<4.00
GRPH	0.400	0.400-1.50	100	<0.500-1.03	<0.600	<0.400	<0.600	<0.500	<1.50	NA	<20	NA	<20	<0.400
BTEX (8020/ 8020 Mod.)			10 Total BTEX	<0.125-<0.20	<0.150	<0.100	<0.150	<0.125	<0.425					
Benzene	0.020	0.020-0.085	0.5	<0.025-<0.040	<0.030	<0.020	<0.030	<0.025	<0.085	<1[c]	<1	<1	<1	<0.020
Toluene	0.020	0.020-0.085		<0.025-<0.040	<0.030	<0.020	<0.030	<0.025	<0.085	<1[c]	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.020-0.085		<0.025-<0.040	<0.030	<0.020	<0.030	<0.025	<0.085	<1[c]	<1	<1	<1	<0.020
Xylenes (Total)	0.040	<0.040-0.710		<0.050-<0.080	<0.060	<0.040	<0.060	<0.050	<0.170	<2[c]	<2	<2	<2	<0.040
VOC 8010	0.020	0.020-0.085		<0.025-<0.040	<0.030	<0.020	<0.030	<0.025	<0.085	NA	<1	<1	<1	<0.020
VOC 8260	0.020	0.020		<0.025-<0.035	NA	<0.020	NA	NA	NA	<1	<1-5.7	<1	<1	<0.020
SVOC 8270														
bis (2-Ethyl-hexyl) phthalate	0.200	0.210	50	<0.240-<1.00	NA	0.447	NA	NA	NA	NA	<10	NA	<10	<0.200
Pesticides	0.001	0.002-0.060		<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	<0.002-<0.030	<0.002-<0.060	NA	NA	NA	NA	<0.002-<0.020
PCBs	0.020	0.020	10	<0.020	<0.020	<0.020	<0.020	<0.020	<0.060	NA	NA	NA	NA	<0.020

☐ CT&E Data.
NA Not analyzed.
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c BTEX determined by 8260 method analysis.
d The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-4. OLD LANDFILL/DUMP SITE EAST ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)
Matrix: Soil/Sediment
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples: S06 & S09 (Replicates)		S07	S08	SD01 & SD02 (Replicates)		Field Blanks: AB01	EB01	TB01	Lab Blanks	
Laboratory Sample ID Numbers					4202-13	4202-16	4202-14	4202-15	4123-9 4202-17	4202-18	4180-3	4204-9 4121-7 4122-7	4122-8 4204-8	4122 4204 4180	4202 4123
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	<4.00	<4.00	173[c]	6.01[c]	111J[c]	79J[c]	NA	NA	NA	NA	<4.00
GRPH	0.400	0.400-0.500	100	<0.500-1.03	<0.400	<0.400	<0.400	<0.400	<0.400	<0.500	NA	<20	NA	<20	<0.400
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.125-<0.20	<0.100	<0.100	<0.100	<0.100	<0.100	<0.125					
Benzene	0.020	0.020-0.025	0.5	<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.020	<0.025	NA	<1	<1	<1	<0.020
Toluene	0.020	0.020-0.025		<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.020	<0.025	NA	<1	<1	<1	<0.020
Ethyl-benzene	0.020	0.020-0.025		<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.020	<0.025	NA	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.040-0.050		<0.050-<0.080	<0.040	<0.040	<0.040	<0.040	<0.040	<0.050	NA	<2	<2	<2	<0.040
VOC 8010	0.020	0.020		<0.025-<0.040	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	NA	<1-7	<1	<1	<0.020
VOC 8260	0.020	0.025		<0.025-<0.035	NA	NA	NA	NA	<0.025	NA	<1	<1-5.7	<1	<1	<0.020
SVOC 8270															
4-Methyl-phenol	0.200	0.240		<0.240-<1.00	NA	NA	NA	NA	0.58	NA	NA	<10	NA	<10	<0.200
di-n-Butyl-phthalate	0.200	0.240	8,000	<0.240-<1.00	NA	NA	NA	NA	0.74	NA	NA	<10	NA	<10	<0.200
Pesticides	0.001	0.002-0.020		<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	NA	NA	NA	NA	<0.002-<0.020
PCBs	0.020	0.020	10	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	NA	NA	NA	NA	<0.020

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-4. OLD LANDFILL/DUMP SITE EAST ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)
Matrix: Soil/Sediment
Units: mg/kg
METALS ANALYSES

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples							Field Blanks			Lab Blanks
					S02	SD01							EB01		
Laboratory Sample ID Numbers					4123-8	4123-9							4121-7		4123 4121
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg							µg/L		µg/L
Aluminum	0.35	2		1,500-25,000	2,400	1,700							<100		<100
Antimony	N/A	53-58		<7.8-<230	<53J	<58J							<100		<100
Arsenic	0.11	5.3-5.8		<4.9-8.5	<5.3	<5.8							<100		<100
Barium	0.024	1		27-390	19	32							<50		<50
Beryllium	N/A	2.6-2.9		<2.6-6.4	<2.6	<2.9							<50		<50
Cadmium	0.33	2.6-2.9		<3.0-<36	<2.6	<2.9							<50		<50
Calcium	0.69	4		360-59,000	16,000J	34,500							<200		<200
Chromium	0.066	1		<4.3-47	18	6.7							<50		<50
Cobalt	N/A	53-58		<5.1-12	<53	<58							<100		<100
Copper	0.045	1		<2.7-45	13	6.2							<50		<50
Iron	0.50	2		5,400-35,000	7,400	7,000							<100		<100
Lead	0.13	2-5.8		<5.1-22	40	<5.8							<100		<100
Magnesium	0.96	4		360-7,400	1,680	1,600							<200		<200
Manganese	0.025	1		25-290	76	50.5							<50		<50
Molybdenum	N/A	2.6-2.9		<2.5-<11	<2.6	<2.9							<50		<50
Nickel	0.11	1		4.2-46	6.7	7.5							<50		<50
Potassium	23	260-2,900		<300-2,200	<260	<2,900R							<5,000		<5,000

☐ CT&E Data.
N/A Not available.
J Result is an estimate.
R Result has been rejected.

TABLE G-4. OLD LANDFILL/DUMP SITE EAST ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)
Matrix: Soil/Sediment
Units: mg/kg
METALS ANALYSES

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples							Field Blanks			Lab Blanks
					S02	SD01							EB01		
Laboratory Sample ID Numbers					4123-8	4123-9							4121-7		4123 4121
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg							µg/L		µg/L
Selenium	1.2	53-58		<7.8-<170	<53	<58							<100		<100
Silver	0.53	2.6-2.9		<3-<110	<2.6	<2.9							<50		<50
Sodium	0.55	5		<160-680	690	<150							340		<250
Thallium	0.011	0.3		<0.2-<1.2	<0.3	<0.3							<5		<5
Vanadium	0.036	1		6.3-59	8.0	6.5							<50		<50
Zinc	0.16	1		9.2-95	34	30							<50		<50

☐ CT&E Data.

TABLE G-4. OLD LANDFILL/DUMP SITE EAST ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)
Matrix: Surface Water
Units: µg/L

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples: SW01 & SW03 (Duplicates)		Environmental Samples: SW02			Field Blanks: AB01	Field Blanks: EB01	Field Blanks: TB01	Lab Blanks
Laboratory Sample ID Numbers					4121-3 4204-3 4122-3	4204-5	4204-4			4180-3	4204-9 4121-7 4122-7	4122-8 4204-8	4204/4180 4122/4121
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L			µg/L	µg/L	µg/L	µg/L
DRPH	100	100		<200	1,840J[ac]	1,450J[ac]	1,870[ac]			NA	NA	NA	<100
GRPH	20	20-125		<20	<20	<20	<125			NA	<20	NA	<20
BTEX (8020/8020 Mod.)													
Benzene	1	1	5	<1	<1	<1	<1			NA	<1	<1	<1
Toluene	1	1	1,000	<1	<1	<1	1.2			NA	<1	<1	<1
Ethylbenzene	1	1	700	<1	<1	<1	7.6			NA	<1	<1	<1
Xylenes (Total)	2	2	10,000	<2	<2	<2	19.2			NA	<2	<2	<2
VOC 8010	1	1		<1	<1	<1-4U	<1			NA	<1-7	<1	<1
VOC 8260													
1,2-Dichloroethane	1	1	5	1.9B-4.5B	<1	1.6B	NA			<1	1.1	<1	<1
SVOC 8270	10	10		<10	<10	<10	NA			NA	<10	NA	<10
Pesticides	0.05	0.1-3		<0.1-<2	<0.1-<2	<0.2-<3	<1			NA	NA	NA	<0.1
PCBs	1	1-3	0.5	<2	<2	<3	<1			NA	NA	NA	<1
TOC	5,000	5,000		17,000-30,700	12,500	13,100	NA			NA	NA	NA	<5,000
TSS	100	200		13,000-19,000	34,000	28,000	NA			NA	NA	NA	<200
TDS	10,000	10,000		241,000-1,853,000	419,000	359,000	NA			NA	NA	NA	<10,000

☐ CT&E Data.
NA Not analyzed.
B The analyte was detected in the associated blank.
J Result is an estimate.
U Compound is not present above the concentration listed.
a Total hydrocarbons in these water samples exceed the 15 µg/L stated for fresh water in ADEC's Water Quality Criteria 18AAC70 (ADEC 1989).
c EPH pattern is not consistent with an unweathered middle distillate fuel.

TABLE G-4. OLD LANDFILL/DUMP SITE EAST ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)

Matrix: Surface Water
Units: µg/L

METALS ANALYSES: TOTAL
(DISSOLVED)

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples							Field Blank			Lab Blank
					SW01 & SW03 (Duplicates)								EB01		
Laboratory Sample ID Numbers					4121-3	4121-4							4121-7		4121
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L							µg/L		µg/L
Aluminum	17.4	100		<100-350 (<100-340)	610 (<100)	<100 (<100)							<100 (<100)		<100 (<100)
Antimony	N/A	100	6	<100 (<100)	<100 (<100)	<100 (<100)							<100 (<100)		<100 (<100)
Arsenic	5.3	100	50	<100 (<100)	<100 (<100)	<100 (<100)							<100 (<100)		<100 (<100)
Barium	1.2	50	2,000	<50-93 (<50-91)	74 (52)	59 (52)							<50 (<50)		<50 (<50)
Beryllium	N/A	50	4	<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Cadmium	1.7	50	5	<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Calcium	34.5	200		4,500-88,000 (4,100-86,000)	50,000 (47,000)	48,000 (47,000)							<200 (<200)		<200 (<200)
Chromium	3.29	50	100 50	<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Cobalt	N/A	100		<100 (<100)	<100 (<100)	<100 (<100)							<100 (<100)		<100 (<100)
Copper	2.3	50	1,300	<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Iron	25	100		180-2,800 (<100-1,600)	3,600 (120)	2,100 (120)							<100 (<100)		<100 (<100)
Lead	6.6	100	15	<100 (<100)	<100 (<100)	<100 (<100)							<100 (<100)		<100 (<100)

☐ CT&E Data.
N/A Not available.

TABLE G-4. OLD LANDFILL/DUMP SITE EAST ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Old Landfill/Dump Site East (LF06)

Matrix: Surface Water
Units: µg/L

METALS ANALYSES: TOTAL
(DISSOLVED)

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples							Field Blank			Lab Blank
					SW01 & SW03 (Duplicates)								EB01		
Laboratory Sample ID Numbers					4121-3	4121-4							4121-7		4121
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L							µg/L		µg/L
Magnesium	47.8	200		2,900-53,000 (2,600-54,000)	18,000 (18,000)	18,000 (18,000)							<200 (<200)		<200 (<200)
Manganese	1.24	50		<50-510 (<50-120)	130 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Molybdenum	N/A	50		<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Nickel	5.5	50	100	<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Potassium	1,154	5,000		<5,000-5,000 (5,000-5,000)	<5,000 (<5,000)	<5,000 (<5,000)							<5,000 (<5,000)		<5,000 (<5,000)
Selenium	62.4	100	50	<100 (<100)	<100 (<100)	<100 (<100)							<100 (<100)		<100 (<100)
Silver	2.6	50	50	<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Sodium	27.7	250		8,400-410,000 (8,200-450,000)	73,000 (75,000)	71,000 (78,000)							340 (330)		<250 (<250)
Thallium	0.57	5-10	2	<5 (<5)	<5 (<5)	<5 (<10)							<5 (<5)		<5 (<5)
Vanadium	1.8	50		<50 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)
Zinc	8.2	50		<50-160 (<50)	<50 (<50)	<50 (<50)							<50 (<50)		<50 (<50)

☐ CT&E Data.
N/A Not available.

TABLE G-5. FUEL STORAGE AREA ANALYTICAL DATA SUMMARY

Installation: Bullen Point Matrix: Soil/Sediment
Site: Fuel Storage Area (ST09) Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks	
					S01	S02 & S05 (Replicates)		S03	S04	SD01	AB01	EB02	TB02		
Laboratory Sample ID Numbers					4177-6 4201-9	4201-10	4201-13	4201-11	4201-12	4201-14	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4201 4177
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4-157	3,830J	32.5[d]	28.9[e]	497	941	45.6[f]	NA	<200	NA	<200	<4.00
GRPH	0.400	0.400	100	<0.5-1.03	406	7.58	4.94	126	357	2.24	NA	<20	NA	<20	<0.400
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.125-<0.2	8.768J	0.183	0.073	2.666	3.523	0.028					
Benzene	0.020	0.020-0.030	0.5	<0.025-<0.04	0.035	<0.030	<0.020	<0.020	<0.020	<0.020	<1[c]	<1	<1	<1	<0.020
Toluene	0.020	0.020-0.030		<0.025-<0.04	0.533J	<0.030	<0.020	0.029	0.073	<0.020	<1[c]	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.020-0.030		<0.025-<0.04	1.57	0.039	<0.020	0.608	0.485	<0.020	<1[c]	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.040-0.060		<0.05-<0.08	6.63	0.144	0.073	2.029	2.965	0.028[b]	<2[c]	<2	<2	<2	<0.040
VOC 8260															
n-Butylbenzene	0.020	0.120		<0.025-<0.035	0.857J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
sec-Butylbenzene	0.020	0.120		<0.025-<0.035	0.303J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.120		<0.025-<0.035	0.182J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
Isopropylbenzene	0.020	0.120		<0.025-<0.035	0.170J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
p-Isopropyltoluene	0.020	0.120		<0.025-<0.035	0.581J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
Naphthalene	0.020	0.120		<0.025-<0.035	4.37J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
n-Propylbenzene	0.020	0.120		<0.025-<0.035	0.259J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
1,2,4-Trimethylbenzene	0.020	0.120		<0.025-<0.035	2.71J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
b Result is indicative of p&m-xylenes only.
c BTEX determined by 8260 method analysis.
d The laboratory reported that 10.9 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.
e The laboratory reported that 11.9 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.
f The laboratory reported that 18.7 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-5. FUEL STORAGE AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point Matrix: Soil/Sediment
Site: Fuel Storage Area (ST09) Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks	
					S01	S02 & S05 (Replicates)		S03	S04	SD01	AB01	EB02	TB02		
Laboratory Sample ID Numbers					4177-6 4201-9	4201-10	4201-13	4201-11	4201-12	4201-14	4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4201 4177
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
1,3,5-Trimethylbenzene	0.020	0.120		<0.025-<0.035	0.848J	NA	NA	NA	NA	NA	<1	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.240		<0.050-<0.070	1.427J	NA	NA	NA	NA	NA	<2	<2	<2	<2	<0.040
SVOC 8270															
Naphthalene	0.200	0.230		<0.240-<1.00	3.20	NA	NA	NA	NA	NA	NA	<11.2	NA	<10	<0.200
2-Methylnaphthalene	0.200	0.230		<0.240-<1.00	3.32	NA	NA	NA	NA	NA	NA	<11.2	NA	<10	<0.200
di-n-Butylphthalate	0.200	0.230	8,000	<0.240-<1.00	0.534	NA	NA	NA	NA	NA	NA	<11.2	NA	<10	<0.200

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.

TABLE G-5. FUEL STORAGE AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point — Matrix: Soil
Site: Fuel Storage Area (ST09) — Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Sample						Field Blanks		Lab Blanks	
					2S06						2EB03	2TB03		
Laboratory Sample ID Numbers					1860						1864	1866	#1&2-9793	#1&2-9793 #5-9693
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg						µg/L	µg/L	µg/L	mg/kg
DRPH	6	60	500[a]	<4-<157	<60[b]						NA	NA	NA	<50
GRPH	0.1	1	100	<0.5-1.03	<1J[b]						<50J[b]	<50J[b]	<50J	<1J
RRPH (Approx.)	12	120	2,000[a]	NA	<120						NA	NA	NA	<100
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.125-<0.2	<0.16									
Benzene	0.002	0.02	0.5	<0.025-<0.04	<0.02						<1	<1	<1	<0.02
Toluene	0.002	0.02		<0.025-<0.04	<0.02						<1	<1	<1	<0.02
Ethylbenzene	0.003	0.03		<0.025-<0.04	<0.03						<1	<1	<1	<0.02-<0.03
Xylenes (Total)	0.009	0.09		<0.05-<0.08	<0.09						<2	<2	<2	<0.04-<0.09

☐ CT&E Data.
▩ F&B Data.
NA Not analyzed.
J Result is an estimate.
a The action levels for DRPH and GRPH are based on conversations with ADEC; final action levels have not yet been determined.
b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

TABLE G-5. FUEL STORAGE AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point — Matrix: Surface Water
Site: Fuel Storage Area (ST09) — Units: µg/L

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Sample						Field Blanks			Lab Blanks
					SW01						AB01	EB02	TB02	
Laboratory Sample ID Numbers					4205-5 4180-7						4180-3	4180-2 4180-1 4205-1	4180-9 4205-7	4180 4205
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L						µg/L	µg/L	µg/L	µg/L
DRPH	100	100		392[ad]-457[ad]	554[ad]						NA	<200	NA	<200
GRPH	20	20		<20	<20						NA	<20	NA	<20
BTEX (8020/8020 Mod.)														
Benzene	1	1	5	<1	<1						NA	<1	<1	<1
Toluene	1	1	1,000	<1	<1						NA	<1	<1	<1
Ethylbenzene	1	1	700	<1	<1						NA	<1	<1	<1
Xylenes (Total)	2	2	10,000	<2	<2						NA	<2	<2	<2
VOC 8260														
1,2-Dichloroethane	1	1	5	1.9-4.5	1.7						<1	<1	<1	<1
SVOC 8270	10	10		<10	<10						NA	<11.2	NA	<10
TOC	5,000	5,000		17,000-30,700	31,100						NA	NA	NA	<5,000
TSS	100	200		13,000-19,000	18,000						NA	NA	NA	<200
TDS	10,000	10,000		241,000-1,853,000	1,036,000						NA	NA	NA	<10,000

☐ CT&E Data.
NA Not analyzed.
a Total petroleum hydrocarbons in these water samples exceed the 15 µg/L stated for fresh water in ADEC's Water Quality Criteria 18AAC70 (ADEC 1989).
d The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-6. DRUM STORAGE AREA ANALYTICAL DATA SUMMARY

Installation: Bullen Point — Matrix: Soil
Site: Drum Storage Area (SS10) — Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples					Field Blanks			Lab Blanks	
					S01-1.6	S02-1.5	S03			AB01	EB02	TB02		
Laboratory Sample ID Numbers					4201-4	4177-5 4201-7	4201-8			4180-3	4180-1 4180-2 4205-1	4180-9 4205-7	4180 4205	4177 4201
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	430[d]	775J	<4.00			NA	<200	NA	<200	<4.00
GRPH	0.400	0.400	100	<0.500-1.03	1.72	14.3	<0.400			NA	<20	NA	<20	<0.400
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.125-<0.20	<0.100	<0.100	<0.100							
Benzene	0.020	0.020	0.5	<0.025-<0.040	<0.020	<0.020	<0.020			<1[c]	<1	<1	<1	<0.020
Toluene	0.020	0.020		<0.025-<0.040	<0.020	<0.020	<0.020			<1[c]	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.020		<0.025-<0.040	<0.020	<0.020	<0.020			<1[c]	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.040		<0.050-<0.080	<0.040	<0.040	<0.040			<2[c]	<2	<2	<2	<0.040
VOC 8010	0.020	0.020		<0.025-<0.040	<0.020	<0.020	<0.020			NA	NA	NA	NA	<0.020
VOC 8260	0.020	0.100		<0.025-<0.035	NA	<0.100J	NA			<1	<1	<1	<1	<0.020
SVOC 8270	0.200	0.210		<0.240-<1.00	NA	<0.210	NA			NA	<11.2	NA	<10	<0.200
PCBs	0.020	0.030-0.200	10	<0.020	<0.100	<0.200	<0.030			NA	<2	NA	<1	<0.020

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c BTEX determined by 8260 method analysis.
d The laboratory reported that 119 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-6. DRUM STORAGE AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Drum Storage Area (SS10)

Matrix: Soil
Units: mg/kg

METALS ANALYSES

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Sample							Field Blank			Lab Blanks
					S02								EB02		
Laboratory Sample ID Numbers					4177-5								4180-1		4177 4180
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg								µg/L		µg/L
Aluminum	0.35	2		1,500-25,000	1,400								<100		<100
Antimony	N/A	51		<7.8-<230	<51								<100		<100
Arsenic	0.11	5.1		<4.9-8.5	<5.1								<100		<100
Barium	0.024	1		27-390	19								<50		<50
Beryllium	N/A	2.6		<2.6-6.4	<2.6								<50		<50
Cadmium	0.33	2.6		<3.0-<36	<2.6								<50		<50
Calcium	0.69	4		360-59,000	1,900J								290		<200
Chromium	0.066	1		<4.3-47	2.7								<50		<50
Cobalt	N/A	51		<5.1-12	<51								<100		<100
Copper	0.045	1		<2.7-45	3.4								<50		<50
Iron	0.50	2		5,400-35,000	4,300								<100		<100
Lead	0.13	5.1		<5.1-22	<5.1								<100		<100
Magnesium	0.96	4		360-7,400	1,100J								<200		<200
Manganese	0.025	1		25-290	45J								<50		<50
Molybdenum	N/A	2.6		<2.5-<11	<2.6								<50		<50
Nickel	0.11	1		4.2-46	4.7								<50		<50
Potassium	23	250		<300-2,200	<250								<5,000		<5,000

☐ CT&E Data.
N/A Not available.
J Result is an estimate.

TABLE G-6. DRUM STORAGE AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Drum Storage Area (SS10)
Matrix: Soil
Units: mg/kg

METALS ANALYSES

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Sample							Field Blank			Lab Blanks
					S02								EB02		
Laboratory Sample ID Numbers					4177-5								4180-1		4177 4180
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg								µg/L		µg/L
Selenium	1.2	51		<7.8-<170	<51								<100		<100
Silver	0.53	2.6		<3-<110	<2.6								<50		<50
Sodium	0.55	5		<160-680	52								540J		<250
Thallium	0.011	0.25		<0.2-<1.2	<0.25								<5		<5
Vanadium	0.036	1		6.3-59	4.1								<50		<50
Zinc	0.16	1		9.2-95	14								<50		<50

☐ CT&E Data.
N/A Not available.
J Result is an estimate.

TABLE G-7. BACKGROUND ANALYTICAL DATA SUMMARY

Installation: Bullen Point
Site: Background (BKGD)

Matrix: Soil/Sediment
Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range	Environmental Samples					Field Blanks			Lab Blanks	
					S01	S02	S03	S04	SD01	AB01	EB01	TB01		
Laboratory Sample ID Numbers					4123-1 4202-1	4123-4 4202-2	4123-5 4202-3	4123-6 4202-4	4123-7 4202-5	4180-3	4204-9 4121-7 4122-7	4122-8 4204-8	4121 4122 4180 4204	4202 4123
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	4.00	4.00	500[a]	<4.00-157	<4.00	152[d]	157[d]	33.8[d]	8.43J[d]	NA	NA	NA	NA	<4.00
GRPH	0.400	0.400-0.600	100	<0.500-1.03	<0.500	<0.600	1.03	<0.600	<0.600	NA	<20	NA	<20	<0.400
BTEX (8020/ 8020 Mod.)			10 Total BTEX	<0.125-<0.20	<0.125	<0.150	<0.20	<0.150	<0.150					
Benzene	0.020	0.025-0.040	0.5	<0.025-<0.040	<0.025	<0.030	<0.040	<0.030	<0.030	<1[c]	<1	<1	<1	<0.020
Toluene	0.020	0.025-0.040		<0.025-<0.040	<0.025	<0.030	<0.040	<0.030	<0.030	<1[c]	<1	<1	<1	<0.020
Ethylbenzene	0.020	0.025-0.040		<0.025-<0.040	<0.025	<0.030	<0.040	<0.030	<0.030	<1[c]	<1	<1	<1	<0.020
Xylenes (Total)	0.040	0.050-0.080		<0.050-<0.080	<0.050	<0.060	<0.080	<0.060	<0.060	<2[c]	<2	<2	<2	<0.040
VOC 8010	0.020	0.025-0.040	90	<0.025-<0.040	<0.025	<0.030	<0.040	<0.030	<0.030	NA	<1-7	<1	<1	<0.020
VOC 8260	0.020	0.025-0.035		<0.025-<0.035	<0.030	<0.025	<0.035	<0.025	<0.025	<1	<1-5.7	<1	<1	<0.020
SVOC 8270	0.200	0.240-1.00		<0.240-<1.00	<0.290-<1.00	<0.260	<0.290	<0.240-<1.00	<0.250-<1.00	NA	<10	NA	<10	<0.200
Pesticides	0.001-0.10	0.002-0.020		<0.002-<0.020	<0.002-<0.020	<0.002-<0.020	<0.003-<0.020	<0.002-<0.020	<0.002-<0.020	NA	NA	NA	NA	<0.002-<0.020
PCBs	0.020	0.020	10	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	NA	NA	NA	NA	<0.020

☐ CT&E Data.
NA Not analyzed.
J Result is an estimate.
a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.
c BTEX determined by 8260 method analysis.
d The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-7. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point Matrix: Soil/Sediment
Site: Background (BKGD) Units: mg/kg

METALS ANALYSES

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Bullen Bkgd. Range	Environmental Samples					Field Blank			Lab Blanks
						S01	S02	S03	S04	SD01		EB01		
Laboratory Sample ID Numbers						4123-1	4123-4	4123-5	4123-6	4123-7		4121-7		4123 4121
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		µg/L		µg/L
Aluminum	0.35	2		1,500-25,000	3,800-12,000	5,030	9,700	12,000	10,300	3,800		<100		<100
Antimony	N/A	60-70		<7.8-<230	<60J-<70	<64J	<61	<70	<63	<60J		<100		<100
Arsenic	0.11	6.0-7.0		<4.9-8.5	<6.0-<7.0	<6.4	<6.1	<7.0	<6.3	<6.0		<100		<100
Barium	0.024	1		27-390	28-150	46	120	150	97	28		<50		<50
Beryllium	N/A	3.0-3.5		<2.6-6.4	<3.0-<3.5	<3.2	<3.1	<3.5	<3.2	<3.0		<50		<50
Cadmium	0.33	3.0-3.5		<3.0-<36	<3.0-<3.5	<3.2	<3.1	<3.5	<3.2	<3.0		<50		<50
Calcium	0.69	4		360-59,000	3,100-59,000	59,000	3,100	6,100	43,300	29,000		<200		<200
Chromium	0.066	1		<4.3-47	7.8-20	10	17	20	19	7.8		<50		<50
Cobalt	N/A	60-70		<5.1-12	<60-<70	<64	<61	<70	<63	<60		<100		<100
Copper	0.045	1		<2.7-45	5.8-15	7.4	11	12	15	5.8		<50		<50
Iron	0.50	2		5,400-35,000	7,200-20,600	13,000	12,300	18,700	20,600	7,200		<100		<100
Lead	0.13	2-6.4		<5.1-22	<6.0-9.7	<6.4	7.6	9.7	9.6	<6.0		<100		<100
Magnesium	0.96	4		360-7,400	2,400-7,400	5,100	2,400	2,800	7,400	3,100		<200		<200
Manganese	0.025	1		25-290	65-290	200	130	65	290	70		<50		<50
Molybdenum	N/A	3.0-3.5		<2.5-<11	<3.0-<3.5	<3.2	<3.1	<3.5	<3.2	<3.0		<50		<50
Nickel	0.11	1		4.2-46	9.9-24	14	13	17	24	9.9		<50		<50
Potassium	23	3,000-3,500		<300-2,200	<3,000R-<3,500	<3,200R	<3,100	<3,500	<3,200	<3,000R		<5,000		<5,000

☐ CT&E Data.
N/A Not available.
J Result is an estimate.
R Result has been rejected.

TABLE G-7. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point   Matrix: Soil/Sediment   METALS ANALYSES
Site: Background (BKGD)   Units: mg/kg

Parameters	Detect. Limits	Quant. Limits	Action ᶜLevels	Bkgd. Range from 7 DEW Line Installations	Bullen Bkgd. Range	Environmental Samples					Field Blank			Lab Blanks
						S01	S02	S03	S04	SD01		EB01		
Laboratory Sample ID Numbers						4123-1	4123-4	4123-5	4123-6	4123-7		4121-7		4123 4121
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		µg/L		µg/L
Selenium	1.2	60-70		<7.8-<170	<60-<70	<64	<61	<70	<63	<60		<100		<100
Silver	0.53	3.0-3.5		<3-<110	<3.0-<3.5	<3.2	<3.1	<3.5	<3.2	<3.0		<50		<50
Sodium	0.55	5-170		<160-680	<160-260	<160	<160	<170	<160	260		340		<250
Thallium	0.011	0.3		<0.2-<1.2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3		<5		<5
Vanadium	0.036	1		6.3-59	11-32	14	26	32	27	11		<50		<50
Zinc	0.16	1		9.2-95	29-60	35	33	29	60	30		<50		<50

☐ CT&E Data.

TABLE G-7. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point | Matrix: Surface Water
Site: Background (BKGD) | Units: µg/L

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range	Environmental Samples						Field Blanks			Lab Blanks
					SW01	SW02					AB01	EB01	TB01	
Laboratory Sample ID Numbers					4204-1 4122-1 4121-1	4204-2 4122-2 4121-2					4180-3	4204-9 4122-7	4122-8 4204-8	4121 4122 4180 4204
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L					µg/L	µg/L	µg/L	µg/L
DRPH	100	200		<200	<200	NA					NA	NA	NA	<200
GRPH	20	20		<20	<20	<20					NA	<20	NA	<20
BTEX (8020/8020 Mod.)														
Benzene	1	1	5	<1	<1	<1					<1[c]	<1	<1	<1
Toluene	1	1	1,000	<1	<1	<1					<1[c]	<1	<1	<1
Ethylbenzene	1	1	700	<1	<1	<1					<1[c]	<1	<1	<1
Xylenes (Total)	2	2	10,000	<2	<2	<2					<2[c]	<2	<2	<2
VOC 8010														
1,2-Dichloroethane	1	1	5	4.9-5.2	4.9	5.2					NA	<1	<1	<1
Methylene Chloride	1	1	5	<1	<1	<1					NA	7	<1	<1
VOC 8260														
1,2-Dichloroethane	1	1.0	5	1.9B-4.5B	4.5B	1.9B					<1	1.1	<1	<1
Methylene Chloride	1	1.0	5	<1	<1	<1					<1	5.7	<1	<1
Toluene	1	1.0	1,000	<1	<1	<1					<1	2.4	<1	<1
SVOC 8270	10	10		<10	<10	<10					NA	<10	NA	<10

☐ CT&E Data.
NA Not analyzed.
B The analyte was detected in the associated blank.
c BTEX determined by 8260 method analysis.

TABLE G-7. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Background (BKGD)

Matrix: Surface Water
Units: µg/L

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range	Environmental Samples						Field Blanks			Lab Blanks
					SW01	SW02					AB01	EB01	TB01	
Laboratory Sample ID Numbers					4204-1 4122-1 4121-1	4204-2 4122-2 4121-2					4180-3	4204-9 4122-7	4122-8 4204-8	4121 4122 4180 4204
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L					µg/L	µg/L	µg/L	µg/L
Pesticides	0.05	0.1-2		<0.1-<2	<0.1-<2	NA					NA	NA	NA	<0.1
PCBs	1	2	0.5	<2	<2	NA					NA	NA	NA	<1
TOC	5,000	5,000		17,000-30,700	30,700	17,000					NA	NA	NA	<5,000
TSS	100	200		13,000-19,000	13,000	19,000					NA	NA	NA	<200
TDS	10,000	10,000		241,000-1,853,000	1,853,000	241,000					NA	NA	NA	<10,000

☐ CT&E Data.
NA Not analyzed.

TABLE G-7. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point Site: Background (BKGD) Matrix: Surface Water Units: µg/L METALS ANALYSES: TOTAL (DISSOLVED)

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Bullen Bkgd. Range	Environmental Samples				Field Blank			Lab Blank
						SW01	SW02				EB01		
Laboratory Sample ID Numbers						4121-1	4121-2				4121-7		4121
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L				µg/L		µg/L
Aluminum	17.4	100		<100-350 (<100-340)	<100-200 (<100-<100)	200 (<100)	<100 (<100)				<100 (<100)		<100 (<100)
Antimony	N/A	100	6	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)				<100 (<100)		<100 (<100)
Arsenic	5.3	100	50	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)				<100 (<100)		<100 (<100)
Barium	1.2	50	2,000	<50-93 (<50-91)	<50-60 (<50-58)	60 (58)	<50 (<50)				<50 (<50)		<50 (<50)
Beryllium	N/A	50	4	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Cadmium	1.7	50	5	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Calcium	34.5	200		4,500-88,000 (4,100-86,000)	33,000-88,000 (33,000-86,000)	88,000 (86,000)	33,000 (33,000)				<200 (<200)		<200 (<200)
Chromium	3.29	50	100	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Cobalt	N/A	100		<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)				<100 (<100)		<100 (<100)
Copper	2.3	50	1,300	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Iron	25	100		180-2,800 (<100-1,600)	370-950 (180-190)	950 (190)	370 (180)				<100 (<100)		<100 (<100)
Lead	6.6	100	15	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)				<100 (<100)		<100 (<100)

☐ CT&E Data.
N/A Not available.

TABLE G-7. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Bullen Point
Site: Background (BKGD)

Matrix: Surface Water
Units: µg/L

METALS ANALYSES: TOTAL (DISSOLVED)

Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Bullen Bkgd. Range	Environmental Samples				Field Blank			Lab Blank
						SW01	SW02				EB01		
Laboratory Sample ID Numbers						4121-1	4121-2				4121-7		4121
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L				µg/L		µg/L
Magnesium	47.8	200		<5,000-53,000 (2,600-54,000)	10,000-53,000 (11,000-54,000)	53,000 (54,000)	10,000 (11,000)				<200 (<200)		<200 (<200)
Manganese	1.24	50		<50-510 (<50-120)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Molybdenum	N/A	50		<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Nickel	5.5	50	100	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Potassium	1,154	5,000		<5,000 (<5,000)	<5,000 (<5,000)	<5,000 (<5,000)	<5,000 (<5,000)				<5,000 (<5,000)		<5,000 (<5,000)
Selenium	62.4	100	50	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)				<100 (<100)		<100 (<100)
Silver	2.6	50	50	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Sodium	27.7	250		8,400-410,000 (8,200-450,000)	31,000-410,000 (37,000-450,000)	410,000 (450,000)	31,000 (37,000)				340 (330)		<250 (<250)
Thallium	0.57	5	2	<5 (<5)	<5 (<5)	<5 (<5)	<5 (<5)				<5 (<5)		<5 (<5)
Vanadium	1.8	50		<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)
Zinc	8.2	50		<50-160 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50 (<50)		<50 (<50)

☐ CT&E Data.
N/A Not available.